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CONTENTS

International Journal on Environmental Sciences **6** (2) : 147-153, July-December 2015 **Research Article**
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Histopathological Studies on the Effect of Pesticides (Chlorpyrifos 50% + Cypermethrin 5% EC) in Stomach and Intestine of an Air Breathing Teleost - Anabas Testudineus

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ABSTRACT

Pesticides, herbicides and insecticides are used abundantly to control pests, weeds and insects in agricultural fields. Indiscriminate use of pesticides may cause harmful effects on non-target aquatic organisms in general and fishes in particular. *Carbine* pesticide is the combination of cypermethin-5% EC and chlorpyrifos-50%.

Histopathological alteration in the stomach and intestine of non-target air breathing teleost *Anabas testudineus* was studied after sub lethal exposure to combination of chlorpyrifos 50% EC and cypermethrin 50% pesticide at sub-lethal dose 0.2 ppm for 48 hours. Histopathological alteration included distortion of columnar epithelial cell (CEC), damage of gastric glands in stomach. In intestine, histopathological changes in columnar epithelial cells (CEC) and mucous secretory cells are observed.

Key words : Cypermethrin 5% EC+Chlorpyrifos 50%, stomach, intestine, Histopathology.

INTRODUCTION

Pesticides are used abundantly to control pests, weeds and insects in agricultural filed as well as aquatic systems. *Anabas testudineus* locally called Kabai and commonly called climbing perch is a common Indian fresh water fish. It can live out of water for a long period. It is predator and depends on shrimps, ostropods, gastropod shells and young fishes. Male Exhibits parental care. It, very often, enters the crop fields from the adjoining water bodies, particularly during monsoon. Since reservoir fishes are now being increasingly needed as a source of animal protein for the people, the effects of pesticides used in cultivation are to be monitored. The purpose of present study was to assess the histological changes is stomach and intestine of Anabas testudineus exposed to combination of cypermethrin 5% EC+chlorpyrifos 50% which is commonly used to control the insect pest of paddy fields in North Bihar of Muzaffarpur District.

The chemical stability of these compounds and their high toxicity to human domestic animals and aquatic system has led government and researchers to be concerned with their presence in the environment. Studies on various organs of Fishes affected by pesticides, used to control insect pest population, are made by researchers and they found positive results regarding toxicity of these pesticides in Fishes.

There are several workers who have reported on effect of chlorpyrifos 50%+cypermethrin 5%EC

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on *Anabas testudineus* in stomach and intestine on the same line. Senapati et.al., (2012) studied the Ultra structural changes in the alimentary canal of *Anabas testudineus* due to Almix 20WP exposure in laboratory condition. Jabeen et.al (2008) observed biochemical and enzymological alteration in cyprinus carpio after exposure of Almix20wp herbicide. Samanta et.al., (2010) studied the digestive Enzymes activity of *Anabas testudineus* and channa punctatus in field condition after application of Almix20WP herbicide.

MATERIAL AND METHODS

Sixty specimens of *Anabas testudineus* of both sexes measuring 13±47 gm body weight and 7.5 cm ± 11cm length were collected from Market of Muzaffarpur District of North Bihar and were kept in the plastic container for acclimatization to the laboratory condition and they were treated with 0.1% Potassium Permanganate solution for 12-15 min to remove any dermal infection and then fishes were transferred to a large tank known as control tank having adequate amount of water for surviving fishes for 15-20 days in laboratory condition. They were divided into six groups of 10 (Ten) Fish, each group was maintained in various concentration of chlorpyrifos 50%+cypermethrin 5% EC solution like 0.05ppm, 0.1ppm, 0.15ppm, 0.2ppm and 0.25 ppm except the sixth group which was maintained in large water tank to serve as controlled fish. Fishes were maintained in same concentration of chlorpyrifos 50%+ cypermethrin 5% EC by changing the Water every alternate days after feeding the fish with minced goat liver, piece of soybean, piece of snail and liver of chicken etc.

The average physio-chemical condition were maintained during this period. Water of this tank was renewed every day to minimize contamination as well as subjected to gut evacuation period before the experiment.

In present study pesticides used as a toxicant, the stock solution, (chlorpyrifos 50% + cypermethrin 5% EC) was prepared according the the method prescribed by standard method (APHA-AWWA, WEF, 1998) for Experimental Purpose. After bioassay test, stomach and intestine were removed from treated and controlled fish and prepared for Histological observations. Dissected portion of stomach and intestine tissue were fixed in Bruin's solution for 24hrs, then washed with 70% ethyl alcohol. Then tissues were dehydrated through graded ethyl alcohol and embedded in the paraffin wax. Tissues were sectioned by microtome of 5μm thickness. Then tissues were stained with haematoxylin and Eosin (H & E).

The stained or permanent Slide were examined with the help of Compound microscope.

RESULT AND DISCUSSIONS

HISTOPATHOLOGICAL STUDY OF STOMACH

Controlled Condition

Histologically stomach is composed of serosa, muscular layer, sub-mucosa, Mucosa. As stomach has masticatory and digestive functions Mucosa layer is folded into variable depths. It is formed of superficial and glandular epithelium. The glandular epithelium is provided with gastric glands. The gastric glands are simple and tubular and were rounded or elongated in shape. Muscularis layer is thin and penetrated by blood capillaries seen in fig (1&2).

Treated Condition

Degeneration and vacuolation in the basal region of gastric epithelium were noted after sub-lethal dose of chlorpyrifos 50%+cypermethrin 5%EC pesticide (fig 3). Damage of gastric glands was noticed and columnar epithelial cells were degenerated in some area (figure 4).

HISTOPATHOLOGICAL STUDY OF INTESTINE

Controlled condition

In Aanabas testudineus intestine was composed

of four histological layers eg., mucosa, submucosa, muscularis, and serosa'. The intestinal mucosal layer has many intestinal villi. The intestinal Mucosa was composed of columnar epithelial cells with centrally and basally placed nuclei, mucosa cells and leucocytes. Mucous cells were present all over the intestinal mucosa and Intestinal villi were covered by thin layer of tissue matrix. Lamina propria was formed by the loose connective tissue fibers of submucosa layer. Blood cells were present in the laimna propria and submucosa layer. Muscularis layer was formed by the inner-circular muscle fibres and outer longitudinal muscle fibres. The serosa layer was composed

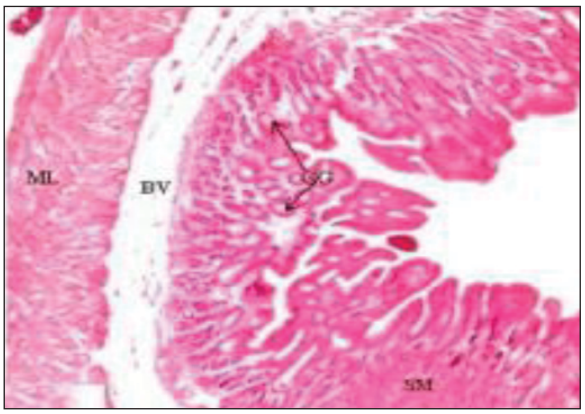
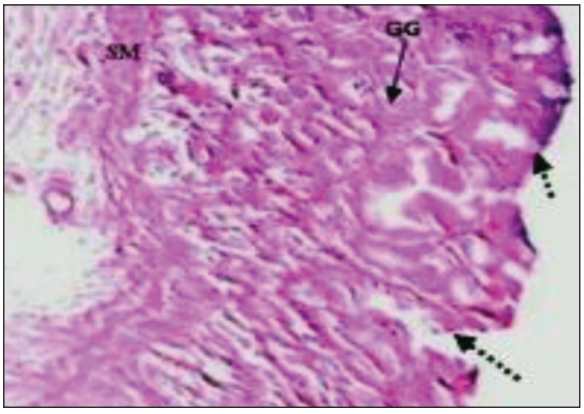


Fig. 1 & 2 : Microphotographs of normal stomach showing superficial epithelium provided with columnar epithelial cells (CEC) and glandular epithelium provided with tubular gastric glands (GG), regular connective tissue network in submucosa (SM).



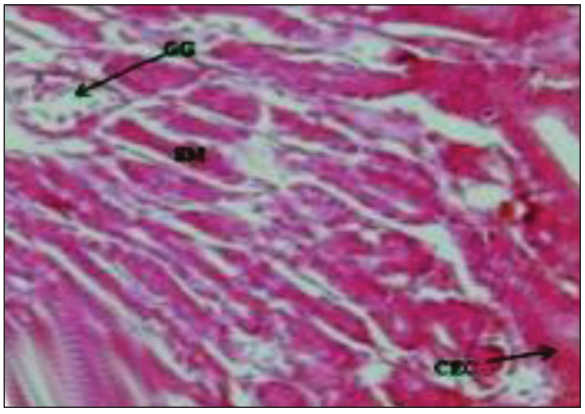
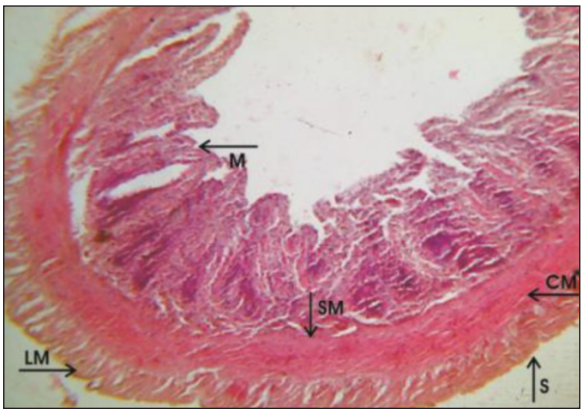


Fig. 3 & 4 : Microphotographs of treated stomach showing degeneration and vacuolation in the basal region of gastric epithelium, distortion of columnar epithelial cells (CEC), degeneration of gastric gland (GG).



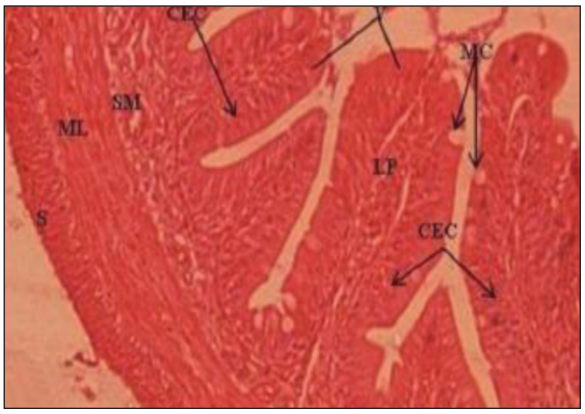


Fig. 5 & 6 : Microphotographs of normal intestine showing outer thin serosa (S), longitudinal muscle fibre (LM), circular muscle fibre (CM), sub-mucosa (SM) and mucosa (M).

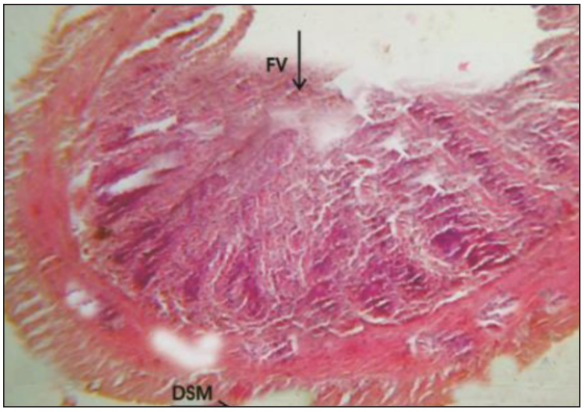


Fig. 7 & 8 : Microphotographs of treated intestine showing degenerated serosa and muscularis (DSM), fusion of villi and degeneration of columnar epithelial sells (CEC) of a single layer of flat cells with blood capillaries and connective tissue fibres in fig (5 and 6).

Treated conditions

Histopathological alteration in the intestine of *Anabas testudineus* after expose of cypermethrin 5%EC+chlorpyrifos 50%, included several structural changes in the intestine like degeneration of columnar epithelial cells (CEC), degeneration of lamina propira (DLP) and prominent luminal mucus secretion shown in figure(7 and 8).

In the present study, distortion of columnar epithelial cells and secretion of mucus the occurred frequently due to Histopathological changes in the stomach of *Anabas testudineus* due to pesticide toxicity. In the stomach, the secretion of Mucous protects the surface layer from gastric acidity and other chemical reaction (Ghosh, 1900), but due to irregular secretion of mucus mucosa and sub-mucosa layer becomes naked and lesions appear.

In similar type of chronic toxicity study, Amminikutty and Rage (1977) reported swelling, distortion and vacuolation with a tendency to

necrotization in the mucosal epithelial cells of stomach of *Gymnocorymbus ternitzi* after chronic exposure of endosulfan and methyl ethyl mercurial. In a recent study, Ghanbahadur and Ghanbahadur (2012) reported vacuolization in the submucosa, shirnkage of Mucosal folds in the stomach of Larvivorous fish *Rasbora daniconius* due the toxic effect of endosulfan. Intestine is the Important part of fish alimentary canal for absorption of digested food.

Mandal and Kulshretha (1980) reported similar type of Histopathological changes in the intestine of *clarias batrachus* due to exposure of sublethal concentration of sumithion. Sharma etal., (2001) also showed similar histological alteration in the intestine of *cirrhinus mrigala* due to toxicological effects of different pesticides.

Ravanaiah and Narasaimha Murthy (2010) reported vocuolization, damage of villi and serosa layer, necrosed mucous epithelium, congested blood capillaries and hyper activity of mucous cells in fish *Tilapia mossambica* exposed to industrial pollutants. Senapati and samanta et.al (2013) reported histological alterations, in stomach and intestine of *Anabas testudineus* after chronic exposure of Almix 20 wp herbicide at a sublethal dose. The distruction of Mucosa and particularly the columnar epithelial cells in the intestine of *Rasbora daniconius* due to endosulfan toxicity was reported by Ghanbahadur and Ghanbahadur (2012). Thus, it becomes clear that the use of pesticides causes detoriation in fish production. Therefore, A restriction must be imposed on the indiscriminate use of these pesticides in agriculture and other related works. So that there should not be any adverse effects on the Aquatic flora and founa.

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International Journal on Environmental Sciences **6** (2) : 154-158, July_December 2015 **Research Article**
(ISSN No.: 0976-4534)

Influence of Season on Quality and *in vitro* Maturation of Sheep Oocytes

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ABSTRACT

The influence of season on oocyte quality is one of the major factors involved in augmenting the reproductive efficiency of livestock. The present study investigated the effect of breeding seasons on quality of sheep oocytes and subsequent cumulus cells expansion, *in vitro* maturation of oocytes. Ovaries were collected from non-pregnant slaughtered sheep from a local slaughterhouse and were washed with 70% ethanol to avoid contamination. Ovaries, having visible follicles with a diameter of 2 to 6 mm, were aspirated during different breeding seasons: summer (March to April), autumn (June to July) and post monsoon season (September to October). Oocytes having more than 5 layers of unexpanded cumulus cells and granular homogenous ooplasm were selected and cultured in maturation medium at 38.5^{o}C, 5% CO2 and 95% humidity for 22-24 hrs. The degree of cumulus cell expansion was determined after 22-24 hrs of IVM and oocyte with expanded cumulus cell mass to at least 2 diameters away from the zona pellucida were considered as cumulus expanded. Our results showed that the percentage of good quality oocytes was 40.1±1.87, 40.89±1.49 and 38.53±0.99%, during summer, autumn and post monsoon seasons, respectively. In summer, autumn and post monsoon seasons, the percentage of fair quality was 39.43±2.94, 37.85±1.73 and 40.74±1.20% and denuded oocytes was 9.81±1.23, 8.43±0.92 and 8.7±0.52%, respectively. The maturation rate was 87.81±1.30, 87.90±1.79 and 88.72±1.58% in summer, autumn and post monsoon seasons, respectively. It is concluded that the developmental competence of sheep oocytes was lower during summer as compared to autumn and post monsoon seasons.

Key words : Oocytes, Sheep, Season; *in vitro* maturation.

INTRODUCTION

In vitro embryo production is an excellent source of embryos for carrying out basic research on developmental physiology, farm animal breeding and for commercial application of the emerging biotechniques. It involves harvesting of oocytes, *in vitro* maturation (IVM) of primary oocytes collected from antral follicles, fertilization of matured secondary oocytes and culture of potential probable embryos to the blastocyst stage. These embryos can then be transferred to recipient females or cryopreserved for future use (Paramio, 2010). In this whole process, two factors are of key importance: obtaining high quality oocytes and successful IVM of the oocytes (Zhou *et al.*, 2008). Immature oocytes could be obtained either from the abattoir ovaries by aspirating the visible follicle (de Smedt et al., 1992) or from live animal by

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laparoscopy or ultrasonography (Wikland *et al.*, 2007).

Elevated ambient temperature (heat stress) is one of the major factors responsible for reduced fertility in farm animals (Ealy *et al.*, 1995). Heat stress can compromise reproductive events by compromising follicular growth (Badinga *et al.*, 1985), hormonal secretion (Wolfenson *et al.* , 1995), uterine blood flow (Roman-Ponce *et al.*, 1978), embryonic function (Ealy *et al.*, 1993) and oocyte developmental potential (Al-Katanani *et al.*, 2002). It was reported that the viability of cow oocytes and embryos is lower during the hot seasons than the cool seasons (Monty and Racowsky, 1987; AI-Katani *et al.*, 2002). This seasonal depression of reproductive performance may be caused by multiple factors, including suboptimal environment or management, as well as age and species-specific sensitivity to those factors (Badinga et al., 1985). Depression in oocyte quality was observed during summer in Holstein cows, however cooling cows for 42 days did not alleviate that seasonal effect (Al-Katanani *et al.*, 2002). Buffaloes had been found to yield fewer good quality oocytes following heat stress than their unstressed counterparts the developmental competence of the oocytes in vitro (Singla et al., 1999). There are very few reports available on the effect of season on ratio of oocyte recovery per ovary and *in vitro* maturation (IVM) in buffalo and cattle but not in sheep. The present study was therefore, undertaken to investigate the effect of the different seasons on the quality of sheep oocytes and their subsequent maturation rate.

MATERIALS AND METHODOLOGY

Collection of the ovaries

Ovaries were collected from sexually mature non-pregnant slaughtered sheep within 30 min of slaughter from the abattoir from a local slaughterhouse and were washed with 70% ethanol to avoid contamination. They were then transported to the laboratory in normal saline (0.9% NaCl). Ovaries having visible follicles with a diameter of 2 to 6 mm were aspirated during different breeding seasons: summer (March to April), autumn (June to July) and post monsoon season (September to October) (Khanvilkar *et al.*, 2009)

Retrieval of oocytes

The extra ovarian tissues were trimmed off and the ovaries were washed thoroughly with 70% ethanol and rinsed three times in pre-warmed fresh normal saline (0.9% NaCl) and cumulus oocytes complexes (COCs) were aspirated from surface follicles (2–6 mm diam.) of ovaries using an 20-G hypodermic needle attached to a syringe containing 0.5-1 mL of aspiration media consisting of TCM-199, Dulbecco's phosphate-buffered saline (PBS), 0.3% bovine serum albumin, heparin (10 µg/ml) and gentamicin (10 µg/ml).

Classification of oocytes

The oocytes were screened by morphological appearance of the cumulus cells investments and homogeneity of ooplasm under a stereo zoom microscope (magnification 300X) as follows: Grade 1: Oocytes with complete compact dense cumulus oophorus having $\geq$ 5 layers of cumulus cells and with transparent homogenous cytoplasm; grade 2: Oocytes with complete compact dense cumulus oophorus with $\leq$ 4 layers of cumulus cells and with transparent homogenous cytoplasm; and grade 3: oocytes without cumulus cells and with irregular (shrunken) cytoplasm. Only oocytes having more than 5 layers of cumulus cells and granular homogenous ooplasm (grade 1) were chosen for the present study.

Maturation of oocytes *in vitro*

The COCs are washed once with aspiration media twice in the medium in which they would be cultured. Five to ten COCs in a group were transferred into 50 μl droplets of oocyte culture media in 35mm petridish. The oocyte culture medium consisted of TCM-199 (Catalogue no. M7528) supplemented with 10% FBS and and

FSH (10 μg/ml). The droplets containing COCs were covered with mineral oil and then the petridishes were placed in a CO2 incubator (38.5°C, 5% CO_2 in air, 90-95% relative humidity) for 24 hours. Oocyte with expanded cumulus cell mass to at least 2 diameters away from the zona pellucida were considered as cumulus expanded. The maturation of oocytes is further evaluated by identifying the first polar body in the perivitelline space after denuding them.

Statistical analysis

The percentage of good, fair, bad and denuded oocytes and in vitro maturation rate were analyzed by one-way ANOVA followed by Tukey's test for comparisons of more than two groups using Graph Pad Prism 5 (Graph Pad Software Inc., San Diego, CA, USA). Differences between mean values were considered significant when the probability values were < 0.05.

RESULTS AND DISCUSSION

The number of ovaries and oocytes collected and the percentage of good, fair, bad and denuded oocytes alongwith the in vitro maturation rate during three breeding seasons: summer, autumn and post monsoon season were presented in Table 1. The average number of ovaries collected during summer, autumn and post monsoon seasons were 54.8±7.25, 61.17±5.95 and 80.00±6.25, respectively. The number of ovaries were significantly (P<0.05) higher in post monsoon season as compared to summer. The number of oocytes recovered decreased in summer which may be due to decrease in available follicles (Hafez, 1993). The number of oocytes recovered per ovary was significantly (P<0.05) different among three season. The recovery rate of oocytes were (P<0.05) significantly higher in autumn seasons when compared to post monsoon season. Our results of lower recovery rate of oocytes during summer agrees with earlier report of Hussain et al (2005) in buffalo which may be due to decrease in available follicles, which are greater in winter, being the breeding season (Hafez, 1993). Similarly, the hot season affected significantly (P<0.05) the number of oocytes collected per animal in Swamp buffalo (Uoc *et al.*, 2007). Sharma and Loganathasamy (2007) reported that variations in the oocyte yield among different studies were due to differences in geographical

Table 1 : Interrelationship between season, quality of oocytes and maturation rate in sheep.

Breeding Seasons	No. of ovaries (Mean± SEM)	No. of oocytes (Mean ± SEM)	Recovery rate of oocytes (Mean ± SEM)	Oocyte quality (%)				Maturation rate (%)
				Good	Fair	Bad	Denuded	
Summer (March to April)	54.80±7.25[a]	62.30±8.45[a]	1.13±0.07[a]	40.1±1.87[a]	39.43±2.94[a]	11.30±1.12[a]	9.81±1.23[a]	87.81±1.30[a]
Autumn (June to July)	61.17±5.95[a]	70.92±7.12[a]	1.15±0.04[a]	40.89±1.49[a]	37.85±1.73[a]	12.54±0.95[a]	8.43±0.92[a]	87.90±1.79[a]
Post monsoon season (September to October)	80.00±6.25[b]	77.33±5.85[a]	0.98±0.04[b]	38.53±0.99[a]	40.74±1.20[a]	8.43±0.92[b]	8.70±0.52[a]	88.72±1.58[a]

[a-b] **Different superscript in the same column differ significantly (P<0.05)**

location in relation to the status of animals slaughtered, season of ovary collection, number of ovaries processed and techniques employed by different workers and criteria for selecting ovaries at slaughter-house might have influenced the oocyte yield in different studies.

The percentage of good quality oocytes was 40.1, 40.89 and 38.53% during summer, autumn and post monsoon season, respectively. In summer, autumn and post monsoon season, the percentage of fair quality was 39.43, 37.85 and 40.74%, respectively. There were no significant differences in good and fair quality oocytes between summer, autumn and post monsoon seasons. The percentage of bad quality oocytes was 11.3, 12.54 and 8.43% during summer, autumn and post monsoon season, respectively. Significant difference ($P<0.05$) was observed in bad quality oocytes between autumn and post monsoon season. The percentage of denuded oocytes was 9.81, 8.43 and 8.7%, during summer, autumn and post monsoon season, respectively. Our results are in agreement with earlier report by Al-Katanani et al. (2002) and Zeron et al. (2001) wherein summer stress depressed the oocyte quality by altering the phospholipid composition of the bovine oocytes. Similarly the poorer yields of oocytes in buffalo during the hot season was due to heat stress which altered endocrine patterns and reduced follicular development (Nandi et al., 2001). Our results showed that the maturation rate was 87.81, 87.90 and 88.72% in summer, autumn and post monsoon season, respectively. No significant difference ($P>0.05$) in maturation rate of oocytes was observed between summer, autumn and post monsoon seasons. Our results corresponded to the results of Tasipro et al. (2013) wherein the average of maturation rates were not different among different three seasons. It is concluded that the developmental competence of sheep oocytes was lower during summer season in comparison to autumn and post monsoon seasons.

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Aromatherapy and Unani Medicine: A Review

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ABSTRACT

Aromatherapy is a modern term for an old age healing art. It is one of the regimens of *Ilaj bit Tadbir* (Regimenal Therapy) employed for the treatment of various ailments under *Unani* system of medicine. Though, the term aromatherapy is new but the basic concept has been taken from *Unani Medicine*, as evident from the review of classical Unani text. The history of Aromatherapy dates back to the period of Buqrat (Hippocrates; 460-377BC). He himself used aromatherapy in the forms of *lakhlakha and shumoom* for the cure of number of diseases. The fundamentals of Unani medicine are based on the teachings of Hippocrates. We can proudly say that aromatherapy has its origin from *Unani Medicine* and is only the revival of the forgotten regimen. This paper reviews the literature relating to use of aromatherapy by Unani physicians in different forms, and explores the scope and application of aromatherapy in present era.

Key words : Aromatherapy, Regimental Therapy, Shumoom, Lakhlakha.

INTRODUCTION

Aromatherapy encompasses the use of essential oils derived from different types of plant sources for a variety of application methods. Generally, the whole fresh plant is used for the essential oil distillation process. The specific ingredients of an essential oil are derived from plant materials or parts that are claimed to possess therapeutic properties. Essential oils are "the steam distillate of aromatic plants"1. They have been described as "the volatile, organic constituents of fragrant plant matter and contribute to both flavor and fragrance and are extracted either by distillation or by cold pressing (expression)"[1]. The history of distillation of essential oils started with the medieval Unani physician Ibn Sina (Avicenna; 980 - 1037) from Persia who invented the process of distillation and was probably the first to distil oil of the rose plant[2]. Today, approximately 40 different oils derived from plants are used in aromatherapy.

Therapeutic aromatherapy is a natural and holistic treatment method that incorporates essential plant oils to treat various body systems[3]. Concentrated essential oils are distilled from various plant materials including flowers, leaves, fruits, roots and peels and are often used in a carrier oil. These aromatic herbal extracts, when employed correctly, hold the capacity to promote wellbeing on the physical, psychological and spiritual levels of an individual. Aromatherapy may be used as a preventative measure as well as an active treatment for acute and chronic diseases. It is a non-invasive modality that acts to support and stimulate the body's natural healing abilities by introducing it to the nervous system by means of inhalation, olfaction and dermal application[4].

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Aromatherapy is currently used worldwide in the management of chronic pain, depression, anxiety, some cognitive disorders, insomnia and stress-related disorders.

Aromatherapy in Classical Unani Medicine

Even though the term aromatherapy was not used until the 20th century, the foundations of aromatherapy date back thousands of years. In particular, the use of essential oils dates back nearly 1000 years. Aromatic plants are described explicitly in classical Unani literature by various eminent scholars like Razi in Kitab ul Mansoori[5], Majoosi in Kamil us Sana[6] and Ibn Hubl Baghdadi in Al Mukhtaraat fit tibb.[7]. Various preparations of aromatic plants like lakhlakha, inkebaab, shamoom are described in these texts.

Process of distillation as adopted and described by Unani physicians confirms the claim that, they were aware of the importance of aromatic drugs and perfumes. There is a vast literature scattered in existing Unani medical books, which shows their intelligential towards the knowledge of herbal drugs including aromatic plants. 'Kitabul-Mia-Lil-Masihi is a book on Unani medicine. Its 17th Chapter consists of aromatic drugs exclusively8.

Desaquredoos (Dioscorides-), a first century Unani surgeon in the Roman army of Nero, included a chapter on fragrant oils in his medical encyclopedia *Kitabul Hashaish* (De Materia Medica), which remained a standard medical text for more than a thousand years. He too made early experiments with the crude distillation of the essential oils of plants producing camphor and turpentine. Before Dioscorides, Unani Physician Buqrat (Hippocrates-460-377 B.C) "the father of medicine", studied the beneficial effects of hundreds of scented plants and herbs. He believed that good health can be promoted with aromatic baths. Hippocrates successfully combated plagues by fumigating the entire city of Athens with aromatic substance, a practice repeated somewhat less systematically centuries later in Europe during its notorious plagues and epidemics[9].

Arab physicians and alchemist added a whole host of new aromatics such as Sana (*Casia occidentalis*), Kafoor (*Cinnamomum camphora*), Jaiphal (*Myristica fragrans*), and Qaranfal (*Syzygium aromaticum*) to the list of medicinal plants, and began to play an important part in the development of herbal and aromatic medicine. Arabs suggested rose and orange-blossom water to make medicines taste more palatable, and they were familiar with the anesthetic effect of inhaled Ajwain Khurasani (*Hyoscyamus niger*) [10]. Arabs were the first who developed the techniques for obtaining essential oil from the naturally occurring organic materials[11]. Arab physician, Avicenna, designed the protocol to extract the essential oil from the flowers by distillation in the tenth century[12,13]. He isolated the perfume in the form of oil or attar from the rose flowers and produced rose water. Essential oils were used extensively in his practice

The earliest systematic compilation of methods for the extraction and distillation of essential oils, the biologically active secretary products of aromatic plants, is found in a pharmacopoeia by Ibn al-Baitar (1198-1248), a pharmacist and Unani physician of the Islamic Golden Age [14].

Yaqub al-Kindi (803-870) invented a wide variety of scent and perfume products, and is considered the father of the perfume industry. He carried out extensive research and experiments in combining various plants and other sources to produce a variety of scent products. He elaborated a vast number of recipes for a wide range of perfumes, cosmetics and pharmaceuticals[15].

The *Kitab Kimiya' al-'Itr (Book of the Chemistry of Perfume)* written by Al-Kindi describes many essential oils including imported Chinese camphor Treatment Methods of Aromatherapy.

There are many versatile ways in which aromatherapy and aromatic medicinal substances are used in *Unani* system of medicine. Broadly speaking, the treatment

methods of aromatherapy can be divided into three categories: external, topical and internal.

External Methods of Treatment

It's undeniable that fragrances have a great power to create a mood or atmosphere that can evoke strong passions, sentiments and memories. Since the olfactory receptors sit right on the underside of the brain, the nose and its sense of smell are the gateway to the mind and spirit.

The vast majority of aromatherapy's external treatment methods involve the release of scents into the air and their inhalation to affect the mind and spirit, to create an atmosphere or mood that will balance out or neutralize any negative emotions or mental states. Various techniques exist for doing this: the burning of incense-Bakhoor16 (Fumigation), the atomization of essential oils-*Inkibab*[16] (Vapor bath), Lakhlakha[16] (Inhalation), *Abzan*[16] (Sitz bath), Pashoya[16] (Foot bath), smelling of the fragrant plants-*Shamum*[16] (Olfaction), Zaroor[16] (sprinkling powder), *Noshookh* (liquid snuff formulations), *Nufookh* (snorting agents), *Atoos* (Errhine), *Sa'oot*[16] (Nasal drop) and *Ghalia* (perfumed powder) or keeping them inside the home like *Rehan* (Tulsi) for this purpose. Because fragrances profoundly impact the mind and spirit, some of these external methods have subtle powers that could be called magical or spiritual.

For example, *Shmum*[17] prepared from *Rehan* (Ocimum sanctum) in *Arq Gulab* (Rosa damascena water) is useful in insomnia. Incenses like *kundur* (*Boswellia carterii*) are burned for spiritual protection, and to dispel any negative entities. In the Middle East, the seeds of the Aspand (*Peganum harmala*) are burnt to release a smoke that protects and purifies against any negative vibrations or entities. *Sa'oot* (Nasal Drops) in addition to opening up the head and sinuses, nose drops can also affect the mind and spirit. *Atoos* (Errhine) have the power to revive consciousness in cases of fainting and syncope. These substances include the crystalline essence of Kafoor (Cinnamomum camphora) and Smelling Salts.

Many different resins may be burnt together as incense, either singly or in combination with others. A list of various resins commonly used in incense making and their fragrances is as follows:

- Amber: Fossilized Pine resin. Somewhat like Pine, but not as warm or full-bodied; darker, and more somber and austere. What is commonly sold as Amber isn't true Amber, but rather, a complex blend of various resins and aromatics; its fragrance is very pungent, warm and full-bodied, with floral overtones.
- Bdellium: The resin of a tree that's closely related to Myrrh, which grows in the Middle East. Called Muqil in Unani Medicine, its botanical name is Commiphora mukul. Dark yet sweet, smelling like a cross between Myrrh and Fir resin.
- Benzoin (Loban): Botanical name Styrax benzoin. An important fixative in perfumery, with a warm, broad, robust, full-bodied scent.
- Borneol: Borneo Camphor, Dryobalanops aromatica. A crystalline essence like Camphor, but with a cooler, mintier aroma. Great when a cool minty scent is desired.
- Camphor: The crystalline essence of the Camphor tree, Cinnamomum camphora, which grows in Southeast Asia and is closely related to Cinnamon. Perhaps the subtlest of all fragrances, Camphor's cool scent imparts a spiritual atmosphere.
- Copal: A favorite of the Incas, Mayas and Aztecs, this resin of the Bursera bipinnata tree hails from Central America. It's delicious fragrance is like a blend of Vanilla, Pine and Myrrh.

- Dragon's Blood: This red resin comes from Calamus draco, a kind of dwarf palm-like tree native to southern Asia. Its scent is spicy and stimulating, sharp but sufficiently warm and full-bodied. An important fixative in perfumery.
- Fir: The resin from Abies picea, a stately evergreen tree. A deliciously sweet, pungent, warm and full-bodied evergreen aroma. A clean, refreshing, wonderful scent.
- Frankincense: The exuded resin of Boswellia carterii, a shrub that grows in the Middle East. Called Kundur in Unani Medicine: a very bright, subtle, light, spicy scent. Because of its protective, purifying, uplifting solar vibrations.
- Juniper: The resin of the evergreen tree Juniperus comunis. Called Abhal in Unani Medicine, Has a bright, light, spicy evergreen scent with fruity overtones.
- Loban: A compounded resinous substance from India with a heavy, pungent floral fragrance that smells somewhat like a combination of Roses, Jasmine and Gardenias.
- Mastic: The resin from the small evergreen tree, Pistachia lentiscus, Called Mastagi in Unani Medicine, which grows only on the Greek Aegean island of Chios. It has a light, bright, subtle scent similar to Frankincense, but softer and broader, with delicate floral and Vanilla-like overtones.
- Myrrh: The resin of Commiphora myrrha, a small tree or shrub that grows in the Middle East. Whereas Frankincense has solar vibrations, those of Myrrh are dark, mysterious and lunar. Myrrh has a bitter, dark, somber aroma with heavy, pungent floral overtones.
- Pine: The exuded resin of various species of Pine, most notably Pinus sylvestris. While having a fresh, evergreen scent, the resins of different species of Pine vary from more crisp, light and austere to more warm, soft and full-bodied.
- Propolis: A blend of various tree resins collected by the bees to protect their hives from infection. A sharp, spicy scent, quite similar to Poplar / Tacamahac or Styrax.
- Spruce: Also known as Douglas Fir (Pseudotsuga canadensis), the resin of Spruce smells quite similar to that of its evergreen cousin, Fir, but it's a bit broader, rounder and more full-bodied.
- Styrax: The gummy, resinous exudate of various species of Ash or Aspen trees. Styrax has an indescribably sharp, clear, transparent scent that is totally unique.
- Tacamahac: The resinous exudate of Balm of Gilead (Populus candicans), which is actually the buds of a species of Poplar tree. To make Tacamahac, which is the purified resin, Balm of Gilead buds are placed in simmering water until their resin melts off and floats up to the surface. The resin is then skimmed off the top with a spoon and collected. A delicious scent that smells like a cross between wine and Roses, with overtones of Myrrh. The European Black Poplar (Populus nigra) buds can be similarly prepared and used, but their scent is warmer, sweeter, and more full-bodied.

Topical Methods of Treatment

Aromatic medicines may be applied topically or to the body surface in a wide variety of different ways, and for a variety of different purposes. The conditions treated may range from superficial skin disorders to conditions of the lungs, colon and other internal organs. This is because aromatic medicines have the power to

penetrate deep into the body. Perhaps it is the most common use of topical aromatic substances is in cosmetics and perfumery. Pleasing fragrances have always been associated with personal sanitation and cleanliness, and hence with hygiene and good health. Different modalities for topical aromatherapy exists in Unani system of medicine such as *Tila*[16] (liniment), *Masuh*[16], *Daluk*[16] (Massaging agent), *Ghaza*[16] (face pack), *Ubtan*[16] (Pack), Qairooti (balsamic pectoral rub) etc.

In traditional Greek Medicine, the female uterus was considered to be a very mobile organ, which was attracted to pleasing fragrances and repelled by unpleasant ones. If the uterus was prolapsed, for instance, a piece of foul-smelling *Halteet* (Asafoetida resin-*Ferula foetida*) would be placed in the crotch under the panties to drive the uterus upwards and away from it, while the woman was instructed to smell pleasing perfumes with her nose to draw the uterus upwards[22].

Ghaza (Face pack) is used to treat various skin disorders, blemishes or infections. For example Rose water and Glycerine is a famous facial beauty treatment, as is a face wash made from an infusion of fresh Elder flowers (Sambucus nigra). Washing the face with a decoction of Sandalwood chips (Santalum album) is a good skin beautifying treatment for acne-prone skin. Tila (liniment) of Qurs Musallas[16] is useful in migraine. Massage oils medicated with the essential oils of Bay Laurel, Cinnamon, Lavender or Cloves have the ability to open the pores and provoke sweating, especially if applied before going into a sauna. They also have the ability to stimulate the circulation of blood and lymph, relax and soothe tense, sore or aching muscles, and ease cramps and spasms.

Sometimes, an aromatic unguent medicated with the essences of Eucalyptus, Menthol and Camphor and other similar substances can be applied to the chest (Qairooti) as a balsamic pectoral rub to treat colds and lung congestion. Such is the penetrating power of aromatics. An embrocation is the application of a powerful essential oil or essential oil blend to certain trigger points to initiate healing reflex reactions by the organism. If possible, the therapeutic properties of the essential oil or essential oil blend used should be consonant with those of the trigger point(s) used. For example, Nutmeg oil, which has a very relaxing, sedative effect, is rubbed into the temples to ease the pain and tension of migraines. Certain healing and disinfectant resins and essences like Camphor, Myrrh, Propolis and Dragon's Blood are common ingredients in tinctures that are used as wound dressings. Many passages in the Bible refer to the application of healing balms and salves to wounds.

By and large, the topical application of aromatics is safe. Care and discretion may be needed with whole body application, as the skin absorption may be considerable. As with anything, some individuals may have idiosyncratic allergic reactions to certain substances.

Internal Methods of Treatment

With internal methods of treatment, the greatest care needs to be exercised in relation to dosage. The danger is minimal or nonexistent if the whole herbs are being used, but when the pure essential oils are used, great care must be taken not to overdose. For internal, oral administration, the usual dose of essential oils is from 3 to 5 drops, no more. Overdosing with the internal use of essential oils can be fatal, hence essential oils are not internally used.

Internal methods of aromatherapy in Unani system of medicine includes use of Mufarrehat16 (exhilarants) and Yaqooti etc[16].

Indications [17-29]

Systems	Diseases
Nervous	Headaches, Anxiety, Depression, Melancholia, Migraine, Insomnia, Amnesia, Night Mares, Epilepsy, Hemiplagia, Facial Palsy, Convulsions, Apoplexy etc.
Cardio-Respiratory	Palpitations, Syncope, Diaphragmitis, Terminal stage of Tuberculosis, Lung Abscess, Bronchiectasis, Empyema, Bronchitis, etc.
Gastro-intestinal	Diarrhoea, Hiccups, Polydipsia, Anorexia, Bulimia, Colitis, Jaundice, Liver Weakness, etc.
Female reproductive	Hysteria, Uterine Prolapsed, Difficult Labour, etc.
Infectious diseases	Plague, Measles, Chicken Pox, Infected wounds etc.

USES

- The aromatic nature of certain herbs and medicines is usually due to the volatile essential oils, oleoresins and resins they contain. The lighter, subtler aromatic principles, usually essential oils, rise to the surface of the body to open the pores of the skin and disperse exogenous pathogenic factors through sweating. Examples of these herbs, called diaphoretics or sudorifics, are Cinnamon (Cinnamomum zeylanicum), Peppermint (Mentha piperita), Elder flowers (Sambucus nigra)34.

- The dynamic, volatile nature of the heavier aromatic principles of plants remains inside the body to move and regulate the flow of various secretions, and the circulation of blood, lymph and other humours. But more importantly, they move and regulate the flow of various vital energies. According to the vitalistic principles of Unani Medicine, the flow of these vital energies moves and regulates the flow of the various secretions and vital fluids of the body25:

The Vital Force (*Quwat-e-Haywaniya*)
It is centered in the heart, chest and lungs. The therapeutic properties of aromatic medicines affecting the flow of the Vital Force in the lungs, chest and heart are: balsamic, bronchiodilators, cardiotonics, and expectorants. Aromatic oils and unguents may also be massaged into the chest from the outside to open up the lungs and respiration. Examples are Eucalyptus (Eucalyptus globulus) and Benzoin gum (Styrax benzoin).

The Natural Force (*Quwat-e-Tabaiya*)
It is centered in the liver and the abdomino-pelvic digestive organs. The therapeutic properties of aromatic medicines affecting the flow of the Natural Force in the abdomino-pelvic digestive organs are: antispasmodic, antiseptic, aperient, carminative, cholagogue, digestive and stomachic. Examples include many common cooking spices e.g. Cardamom, Dill, Fennel, Marjoram, Oregano and Thyme.

The Psychic Force (*Quwat-e-Nafsaniya*)
It is centered in the head, brain and neuromuscular system. The therapeutic properties of aromatic medicines affecting the flow of the Psychic Force in the head, brain and throughout the neuromuscular system include: antispasmodic, anticonvulsant, anodyne, antirheumatic and analgesic. Besides ingestion, they may also be massaged into the muscles; certain others, like Smelling Salts or Camphor, may even be inhaled to revive consciousness in

fainting or syncope. Other examples include Lavender (lavandula officinalis) and Wintergreen (Gaultheria procumbens).

- Another key property of aromatic medicinal is their antiseptic ability to fight infection. From the earliest of times, the great physicians of antiquity realized that, if infection and sepsis produced a foul, putrid odour, that aromatics with pleasing fragrances would have an ability to fight infection; this simple hypothesis worked, and withstood the test of clinical practice. Three notable essential oils are most powerful in their antiseptic properties, and could even be called antimicrobial or even antibiotic. These are the essential oils of thyme (thymus vulgaris), tea tree (melaleuca alternifolia) and oregano (origanum vulgare). Certain aromatic resins from wounded trees, like myrrh (commiphora myrrha), not only have antiseptic properties to fight infection, but also have cicatrizant and vulnerary properties to speed up the granulation and healing of wounds.

Therapeutic Fragrances for the Four Temperaments[31]

Aromatic medicines, like any other medicines, all have their own therapeutic indications and applications. But in Unani Medicine, certain fragrances are, by their very natures, considered to have therapeutic effects on harmonizing and balancing certain temperaments.

Choleric: Overheated passions and fiery tempers are cooled down by fragrances of Camphor. Jasmine, Rose, Sandal wood and Aloe wood etc. Camphor is a specific remedy for cooling down sexual passions, and is an anaphrodisiac.

Melancholic: Melancholic types need fragrances with the special ability to soothe and calm the nerves and relax nervous tension. The best among these are Sumbul ut teeb (Nordostychas Jatamamsi), Khash-Khash (Papaver somniferum), and Lavender (Lavendula stoechas).

Phlegmatic: Phlegmatics, being cold and moist, slow and sluggish, need heating, stimulating fragrances to wake them up and get them moving. These fragrances include Cloves, Cinnamon etc.

Sanguine: The Sanguine temperament, being the most balanced, is also the most versatile and compatible with a wide variety of fragrances. Because the Sanguine temperament is prone to congestion and turbidity of stagnant humors, fragrances with a mildly stimulating, refreshingly clean scent work very well for Sanguines. These fragrances include Peppermint, Tulsi and Cardamom.

Herbs Used for Aromatherapy in Unani Medicine[30-33]

Herb	**Botanical Name**
Ajwain	*Carum coptcum seeds*
Anisoon	*Pimpinella anisum seeds*
Arjun	*Terminalia arjuna bark*
Badam	*Prunus amygdalus fruit*
Barg suddab	*Ruta graveolense leaf*
Badam talkh	*Prunus amygdalus amara fruit*
Badiyan	*Foeniculum vulgare seeds*
Bisbasa	*Myristica fragrans fruit coat*
Dar chini	*Cinnamomum zeylanicum bark*
Gul surkh	*Rosa damascene flowers*
Kundur	*Boswellia serrata gum*
Kafur	*Cinnamomum camphora dried extract*
Vaj	*Acorus calamus root*
Qust	*Saussurea lappa root*
Qaranfal	*Caryophyllus aromaticus bud*
Safaida	*Eucalyptus sp. Leaves*

Heel kalan	*Amomum subulatum fruit*
Heel khurd	*Elettaria cardomomum fruit*
Kunjud	*Sesamum indicum seeds*
Hasha	*Thymus serpyllum/T. Vulgaris*
Parsley	*Petroselinum crispum herb*
Rehan	*Ocimum sanctum herb*
Sada bahar	*Vinca rosea/catharanthus roseus*
S'atar	*Zataria multiflora leaf*
Muqil	*Commiphora mukul gum*
Pepper mint	*Menthe piperita*
Ustukhuddus	*Lavandula steochas flower*
Zoofa	*Hyssopus officinalis flower*
Cedar wood	*Juniperus virginiana*
Jasmine	*Pelargonium odoratissimum*
Orange bitter	*Citrus aurantium*
Lemon	*Citrus lemon*
Afsanteen	*Artemisia absinthium herb*
Abhal	*Juniperus communis fruit*
Zeera siyah	*Carum carvi seeds*
Zeera safaid	*Cuminum cyminum seeds*
Bergamot	*Citrus bergamia*
Orange sweet	*Citrus sinensis*
Podina	*Mentha arvensis herb*
Kashneez	*Coriandrum sativum fruit*
Sadal safaid	*Santalum album*
Myrrh	*Citrus aurantium*
Nutmeg	*Cymbopgon martini*

Safety aspects

It is generally accepted that a safe and effective dilution for most aromatherapy/essential oils in massage therapy is a maximum of 2.5 % for adults, which translates to 2 drops of essential oil per 100 drops of carrier oil (2% dilution: 10-12 drops of essential oil per ounce of carrier oil). For full-body baths, the dosage of essential oil is usually 5–10 drops per bath.

The testing of essential oils for safety has shown minimal adverse effects. A number of oils have therefore been approved for use as food additives and are classified as GRAS (generally recognized as safe) by the U.S. Food and Drug Administration (US Food and Drug Administration). However, some essential oils (e.g. camphor oil) can cause local irritation with prolonged skin contact of oils in case of aromatherapy massage.

Repeated exposure to lavender and tea tree oils by topical administration was shown in one study to be associated with reversible prepubertal gynecomastia35.

DISCUSSIONS AND CONCLUSION

Aromatherap is one of the regimens of Ilaj bit Tadbir (Regimenal Therapy) employed for the treatment of various ailments under Unani system of medicine. Though, the term aromatherapy is new but the basic concept has been taken from Unani Medicine, as evident from the review of classical Unani text. Aromatherapy has been in use and well understood in Unani system of medicine as evident from the review of classical Unani text as well as pharmacopieas such as Al Qanon-fi-Tib, Kitab-al-Murakabat al Maroof Makhzan-al-Murakabat, Firdaus-al-Hikmat-fit-Tib, Tarjuma Sharah Asbab, Kitab-al-Mukhtarat, Kitab-al-Hawi-fit-Tib, Maujaz-al-Qanoon, Ghina Muna, Al-Akseer, Kitab-al-mansoori, Qarabadeen Qadri, Qarabadeen Azam, Biyaz-e-kabir, vol. 2.
Aromatherapy may be used as a preventative measure as well as an active treatment for acute and chronic diseases with some precautions. However, it is necessary to establish aromatherapy as an evidence-based medical therapeutic system through clinical studies and scientific research of essential oils, as well as the substantial accumulation of experience.

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International Journal on Environmental Sciences **6** (2) : 169-178, July_December 2015 **Review Article**
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Role of Crop Habitat Diversification in Chilli (*Capsicum annuum* L.) Pests Management

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ABSTRACT

Field experiments were conducted during kharif 2010-11 and 2011-12, at the Main Agricultural Research Station, UAS, Dharwad, Karnataka, to assess the effect of border and barrier cropping for the management of chilli pests. Chilli border and barrier, cropped with South African tall maize and sweet sorghum, were found superior over sole crop of chilli by recording lowest population of sucking pests, leaf curl index, larval population of *H. armigera* and fruit damage. Same treatments registered significantly higher growth parameters and dry chili yield (3.95 and 3.89 q/ha) with net returns of Rs 19,528/- and C:B ratio of 1: 2.56. Activities of predators i.e. coccinellid and chrysopids, were found greatly distributed in plots having border and barrier crops.

Key words : Border and Barrier cropping, Fruit borer damage, Helicoverpa armigera, leaf curl index, predators, sucking pests.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is a tropical and subtropical crop grown all over India. It is an important versatile spice as well as vegetable crop. India is the largest producer and consumer of chilli in the world. Chillies constitute about 20 per cent of Indian spice exports in quantity and about 14 per cent in value. It's grown in almost all the state throughout the country. Andhra Pradesh is the largest producer of chilli in India and contributes about 30% to the total area, followed by Karnataka (20%), Maharashtra (15%), Orissa (9%), Tamil Nadu (8%) while other states contributing nearly 18% to the total area under chilli. Among the plethora of constraints in chilli cultivation, the attack by a multitude of insect pests and mite at different crop stages is of utmost concern. The pest spectrum of chilli crop is complex with more than 293 insects and mite species debilitating the crop in field as well as in storage (Anon., 1987 and Dey *et al.*, 2001). A total of 39 and 57 species of pests were recorded by Reddy and Puttaswamy (1983 and 1984) in nursery and field crops, respectively in Karnataka. One of the practical means of increasing chilli production is to minimize losses caused by major insect pests, the most important among them are green peach aphid (Myzys persicae Sulzer, Aphis gossypi Glover), thrips (Scirtothrips dorsalis Hood), yellow mite (Polyphagotarsonemus latus Banks) and fruit borer (Helicoverpa armigera Hubner) (Berke and Sheih, 2000). In Karnataka thrips, mites, aphids and whiteflies have been identified as sucking pests of chilli of which chilli leaf curl caused by mite and thrips are serious (Puttarudriah, 1959). Besides, a number of viruses are transmitted by aphids, whiteflies etc which result into a

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complex murda (Gundannavar *et al.*, 2007). The yield losses due to these pests are estimated to be 50 per cent (Ahmed *et al.*, 1987; Kandasamy *et al.*, 1990 and Hosmani, 2007). The loss caused by the thrips is reported to range from 50 to 90 per cent (Borah, 1987) and fruit borers is to an extent of 90 per cent (Reddy and Reddy, 1999).

Massive application of pesticides not only leaves harmful residues in the food chain but also causes effects on non-target organisms and environment, pest resurgence and development of resistance in insects to insecticides. Pesticide residues in chilli are of great concern from the point of domestic consumption and exports as well. Residues in chilli have been reported by various workers in India (Awasthi *et al.*, 2001; Dhotre *et al.*, 2001 and Joia *et al.*, 2001; Singh *et al.*, 2006; Reddy *et al.*, 2007; Rao *et al.*, 2009; Suganthy *et al.*,2010 and Jyoti *et al.*, 2012).With this background experiments were conducted to assess the influence of border and barrier crops on the activity of sucking pests, pod borer and natural enemies populations.

MATERIALS AND METHODS

Field experiments were carried out for two seasons to know the effect of border and barrier cropping system on activity of insect pests of chilli during kharif 2010-11 and 2011-12. The experiment was laid out at the MARS, UAS, Dharwad in deep black cotton soil. The experiment consisted of seven treatments which were replicated thrice in RBD. The treatment details of border and barrier cropping system includes viz., T1 - Sole chilli, T2 - Chilli border cropped with south African tall maize, T3 - Chilli barrier cropped with south African tall maize, T4 - Chilli border and barrier cropped with south African tall maize, T5 - Chilli border cropped with sweet sorghum, T6 - Chilli barrier cropped with sweet sorghum and T7 - Chilli border and barrier cropped with sweet sorghum.

The seedlings of chilli and seeds of African tall maize and sorghum were procured from MARS, UAS, Dharwad and chilli seedling were transplanted during 3rd and 1st week of July 2010-11 and 2011-12 respectively in plots of size 5.4 X 4.8 m. with spacing of 60 X 60 cm. Each plot had a density of 72 hills with two plants per hill. The seeds of African tall maize and sorghum were sown at the time of chilli transplanting all around the main crop. All management practices were followed as per recommended package of practices except the plant protection measures against target pests.

Observations of sucking pests

The population count of aphids and thrips were taken at 30, 60 and 90 days after transplanting (DAT). While the population count of mite was taken at 60 and 90 DAT. For counting the population, five plants were selected randomly in each plot and tagged. Six leaves on the top canopy of each selected plant were observed by using binocular microscope in laboratory following destructive sampling procedure. Ten plants were selected randomly in each plot and scored for leaf curling index (LCI) at 70 and 100 DAT visually following the 0-4 scale (Niles, 1980) and subjected for statistical analysis.

Assessment of larval population of *H. armigera* and fruit damage

The observations on larval population of chilli fruit borer, H. armigera were made on five randomly selected plants from each treatment at 60, 90 and 120 DAT. The per cent fruit damage was worked out by counting total number of fruits per plant and number of damaged fruits per plant on five randomly selected plants in each treatment at every picking. Pooled analysis for both the years was done with the help of M StatC statistical software.

Population of natural enemies

Population count of both grubs and adults of natural enemy fauna that included coccinellid beetles, M. sexmaculatus and chrysopids, C. zastrow sillemi were recorded in each treatment by following the standard procedure followed in ecological studies. Population count was taken on five randomly selected plants at 60 and 90 DAT. The population density of predatory

coccinellids beetles and chrysopids was recorded as number of coccinellids/plant and chrysopids/plant, respectively. Pooled analysis for both the years was done with the help of M StatC statistical software.

Plant height and fruit yield

Growth and yield parameters of chilli at different crop stages as influenced by intercropping were recorded as plant height (cm) at 90 DAT. Height of the plant from the base to the tip of the upper most branch was measured and expressed in centimeter. Green chillies were harvested from five randomly selected plants in each plot as well as from entire plot separately and yield per plant and per plot was recorded during each picking. Total yield was calculated by adding the yield of each picking. Totally four pickings were done and average of four pickings were given. The per plot yield was converted to quintals per hectare. Dry chilli yield was obtained from the green chilli yield as per the procedure given by Anon. (2004), with the ratio of conversion of green chilli to dry chilli being 10:1. Cost effectiveness of each treatment was assessed based on net returns. Net return of each treatment was worked out by deducting total cost of each treatment from gross returns. Total cost of production included both cultivation costs as well as plant protection charges. The B: C ratio was worked out by dividing the gross returns with the total cost of production.

The data on mean population of sucking pests, natural enemies and fruit borer were transformed to x+0.5 and per cent damage was transformed to arcsine transformation and then subjected to one way ANOVA using M-STATC ® software package. The treatment effect was compared by following Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Sucking pest density

Pooled data on aphid population revealed that aphids count in different treatments ranged from 0.22 to 0.47 and 0.19 to 0.38 during 2010-11 and 2011-12, respectively. The treatment chilli border and barrier cropped with South African tall maize registered significantly less number of aphids of 0.22 and 0.19 during 2010-11 and 2011-12, respectively. Moderate pest activity was recorded in treatments like chilli border and barrier cropped with sweet sorghum, chilli border cropped with south African tall maize and chilli barrier cropped with south African tall maize (0.33 aphids/leaf) while sole chilli (control) recorded significantly more number of aphids (0.47 and 0.38/ leaf) during 2010-11 and 2011-12, respectively. Pooled analysis of the data also indicated similar trend of treatment significance (Table 1).

During 2010-11, significantly least thrips population count (0.28/leaf) was registered in chilli with border and barrier crop of South African tall maize followed by chilli border and barrier cropped with sweet sorghum (0.41 thrips/leaf). However, higher number of thrips were found in sole chilli (0.60/leaf). During 2011-12, thrips population varied from 0.23 to 0.71/leaf. All the treatments except sole chilli recorded significantly lower number of thrips. Similar trend was also noticed in pooled data.

Results on mite population indicated that chilli with border and barrier crop of South African tall maize recorded significantly less number of mites (0.41 and 0.39 mites/leaf) during 2010-11 and 2011-12, respectively. All the treatments recorded varied number of mite population per leaf which ranged from 0.41 to 0.89 during 2010-11 and from 0.39 to 0.91 in 2011-12, respectively. However, all the treatments recorded significantly less number of mite compared to sole chilli. Further, the mite population was slightly low during 2011-12, compared to previous year. Maximum number of mite of 0.89 and 0.91/leaf was registered in sole chilli during 2010-11 and 2011-12, respectively. Similar pattern of treatment significance was noticed in pooled data also (Table 1).

Table 1: Population of sucking pests and leaf curl index in chilli border and barrier cropped with different crops

Treatment	Aphid count (No./leaf)			Thrips count (No./leaf)			Mite count (No./leaf)			Leaf curl index		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1- Acetamiprid 20 SP @0.3g/l	0.17e (0.91)	0.16d (0.90)	0.15e (0.89)	0.23e (0.98)	0.21f (0.96)	0.20f (0.95)	0.73bc (1.35)	0.71c (1.34)	0.74c (1.36)	0.46c (1.18)	0.44d (1.16)	0.46d (1.18)
T_2- Thiamethoxam 25 WG @1g/l	0.12f (0.95)	0.11e (0.83)	0.11e (0.91)	0.12f (0.85)	0.11g (0.83)	0.12g (0.85)	0.84ab (1.42)	0.82b (1.41)	0.82b (1.41)	0.29d (1.04)	0.26e (1.01)	0.28e (1.03)
T_3- Thiacloprid 480 SC @ 1ml/l	0.21e (0.96)	0.22d (0.98)	0.22e (0.97)	0.49c (1.27)	0.45d (1.24)	0.47c (1.25)	0.98a (1.49)	0.94a (1.47)	0.96a (1.48)	0.59b (1.27)	0.57cd (1.25)	0.56c (1.24)
T_4- Abamectin 1.8 EC @ 0.5ml/l	0.55b (1.24)	0.52b (1.22)	0.54b (1.23)	0.58b (1.32)	0.52c (1.29)	0.55b (1.31)	0.19d (0.94)	0.15d (0.99)	0.17d (0.91)	0.51b (1.21)	0.48d (1.19)	0.50c (1.20)
T_5- NSKE 5% @ 50ml/l	0.36c (1.10)	0.33c (1.07)	0.35c (1.09)	0.21e (1.03)	0.24f (1.04)	0.21f (1.03)	0.39cd (1.12)	0.32cd (1.07)	0.36cd (1.10)	0.69b (1.33)	0.68bc (1.32)	0.69b (1.33)
T_6- Diafenthiuron 50 WP @0.75g/l	0.21e (0.96)	0.19d (0.94)	0.19e (0.94)	0.20e (0.95)	0.21f (0.96)	0.21f (0.96)	0.18d (0.92)	0.16d (0.90)	0.14d (0.88)	0.24d (0.99)	0.22e (0.97)	0.21e (0.96)
T_7- Buprofezin 10 EC @ 0.75ml/l	0.19e (0.94)	0.16d (0.90)	0.18e (0.92)	0.22e (0.97)	0.22f (0.97)	0.22f (0.97)	0.24d (0.99)	0.20d (0.95)	0.23d (0.98)	0.41c (1.14)	0.38d (1.12)	0.40d (1.13)
T_8- Novaluron 10 EC @ 0.75ml/l	0.61a (1.24)	0.57a (1.22)	0.60a (1.23)	0.92a (1.46)	0.91a (1.45)	0.92a (1.46)	0.97a (1.48)	0.81b (1.40)	0.89a (1.44)	0.91a (1.45)	0.93a (1.46)	0.94a (1.47)
T_9- Emamectin benzoate 5 SG @ 0.4g/l	0.64a (1.30)	0.61a (1.28)	0.62a (1.29)	0.89a (1.44)	0.82b (1.41)	0.86a (1.43)	0.41cd (1.14)	0.39cd (1.12)	0.40cd (1.13)	0.93a (1.46)	0.91a (1.45)	0.91a (1.45)
T_{10}- Spinosad 45 SC @ 0.3ml/l	0.59ab (1.27)	0.47b (1.19)	0.51b (1.22)	0.40cd (1.13)	0.38de (1.12)	0.36d (1.10)	0.96a (1.48)	0.93a (1.46)	0.95a (1.47)	0.78ab (1.38)	0.75b (1.37)	0.77ab (1.38)
T_{11}- Imidacloprid 17.8 SL @ 0.3ml/l	0.19e (0.94)	0.15d (0.89)	0.18e (0.93)	0.29d (1.04)	0.28e (1.03)	0.29e (1.04)	0.87ab (1.43)	0.84b (1.42)	0.86b (1.43)	0.32cd (1.07)	0.29e (1.04)	0.31de (1.06)
T_{12}- Propargite 57 EC @ 2.5ml/l	0.37c (1.09)	0.35c (1.07)	0.35c (1.07)	0.45c (1.31)	0.42d (1.29)	0.44c (1.30)	0.23d (0.98)	0.20d (0.95)	0.22d (0.97)	0.38c (1.12)	0.36d (1.10)	0.36d (1.10)
T_{12}- Profenofos 50 EC @ 2ml/l	0.23de (0.99)	0.21de (0.96)	0.20de (0.95)	0.31d (1.06)	0.30e (1.05)	0.31e (1.06)	0.31cd (1.06)	0.27d (1.02)	0.29cd (1.04)	0.37c (1.11)	0.35de (1.09)	0.36d (1.10)
T_{14}- Garlic Chilli Kerosene Extract 0.5% @ 5ml/l	0.31d (1.06)	0.29c (1.04)	0.30d (1.05)	0.31d (1.06)	0.29e (1.04)	0.30e (1.05)	0.42cd (1.15)	0.37cd (1.11)	0.40cd (1.13)	0.58b (1.26)	0.55d (1.24)	0.57c (1.25)
T_{15}- Untreated check	0.67a (1.32)	0.64a (1.30)	0.66a (1.31)	0.95a (1.49)	0.93a (1.47)	0.96a (1.50)	1.01a (1.51)	0.96a (1.48)	0.97a (1.49)	0.95a (1.46)	0.92a (1.45)	0.94a (1.46)
CV	11.60	11.40	11.63	12.50	7.82	9.29	9.86	7.95	6.52	6.15	6.72	6.13
S. Em±	0.01	0.03	0.02	0.03	0.01	0.02	0.03	0.02	0.02	0.06	0.04	0.05
C.D. at 5%	0.04	0.09	0.06	0.08	0.04	0.06	0.08	0.06	0.05	0.17	0.11	0.15

Figures in parenthesis are arc sine transformed values
In a column means followed by the same alphabet did not differ significantly by DMRT (0.05)

Observations on leaf curl index revealed that chilli border and barrier cropped with South African tall maize recorded significantly less leaf curl score of 0.36 and 0.29 during 2010-11 and 2011-12, respectively. All treatments were found to be significantly superior over control (sole chilli). Moderate leaf curl disease score was recorded in chilli border and barrier cropped with sweet sorghum (0.39 and 0.31), chilli barrier cropped with South African tall maize (0.49 and 0.44), chilli border cropped with sweet sorghum (0.51 and 0.47), chilli border cropped with South African tall maize (0.56 and 0.59) and chilli barrier cropped with sweet sorghum (0.64 and 0.65) during both the years. Similar trend was also noticed for pooled data. When extent of LCI for pooled data was seen, the treatments grouped in the order of T1 > T6 > T2 > T5 >T3> T7 > T4.

Since, aphids, thrips, mites and whiteflies are the soft bodied, small and fragile insects, they are dispersed from one place to another through wind currents. When borders and barriers are used around and within the main crop, dispersal of these insects is physically prevented by the thick plant canopy, thus preventing or reducing the spread of the sucking pests to main crop. Besides, they also may promote build up of natural enemies because of provision of food (eg. Nector, pollen etc.) to the parasites and predators which in turn reduce the pest population on the main crop. However, Tatagar *et al.* (2011) reported that chilli crop bordered by two rows of maize recorded least leaf curl damage due to lower number of thrips and mite and found significantly superior to all other treatments and standard check. Similar results were also obtained by Shivaprasad *et al.* (2011) who

concluded that lower level of leaf curl index as a consequence of lower thrips and mites population and increased predator population in crop under fodder and grain sorghum barriers compared to chilli crop without barrier.

Growing of fodder and grain sorghum in six to nine row strips after every 40 rows of chilli in north-west or south-east direction that is against the prevailing winds could be adopted advantageously to manage the menace of murda caused by thrips and mites incidence (Shivaprasad *et al.*, 2011).

H. armigera

The data presented in Table 2 indicated that fruit borer larval density in different treatments varied from 0.28 to 0.48 and 0.31 to 0.61/plant during 2010-11 and 2011-12, respectively. The treatments chilli with border and barrier crop of South African tall maize recorded significantly less number of fruit borer of 0.28 and 0.31 during 2010-11 and 2011-12, respectively followed by chilli border and barrier cropped with sweet sorghum (0.31 and 0.34/plant). Maximum number of fruit borer larval density of 0.48 and 0.61/plant was registered in sole chilli during 2010-11 and 2011-12 respectively. Pooled data also recorded same pattern of treatment significance.

chilli border and barrier cropped with south African tall maize recorded significantly less fruit borer damage (3.49 and 3.44%) which was on par with the treatment chilli border and barrier cropped with sweet sorghum (3.60 and 3.78 %) during 2010-11 and 2011-12 respectively. While all other treatments except sole chilli recorded significantly least fruit borers damage per cent. Maximum fruit damage of 5.37 and 5.12 per cent were registered in sole chilli during 2010-11 and 2011-12 respectively. Similar pattern of treatment significance was noticed in pooled data also. Lower activity of fruit borer in the crop could be attributed to presence of certain volatile substance present in the border and barrier crop plants, that might restrict colonization on the main crop. Further, border and barrier cropping system helps in habitat manipulation in maintaining the eco-balance and provides favorable conditions for natural enemies of fruit borer as well, thus sustaining crop productivity. Nelson and Natarajan (1994) revealed that chilli bordered with agathi and protected with insecticides recorded significantly lower incidence of thrips and aphids compared to control, whereas fruit borer incidence was less in castor bordered with chilli. Dhandapani *et al.* (2003) recorded in brinjal that intercropping with single and double rows of coriander Coriandrum sativum (L.) as well as border crop of brinjal, significantly reduced the incidence of brinjal shoot and fruit borer.

Predators

Predators observed in the experimental field were coccinellid beetles, M. sexmaculatus and C. zastrow sillemi . The data scan on the activity of predators, suggest that the predators were found greatly distributed in plots having different border and barrier cropping versus to sole chilli. The details of the results are presented below.

During 2010-11, the population of coccinellid ranged from 0.95 to 1.71 per plant. Significantly higher number of coccinellids (1.71 per plant) was noticed in chilli border and barrier cropping with South African tall maize plot, whereas in sole chilli plot least population of 0.95 coccinellids per plant were observed. During 2011-12 also significantly higher number of 1.65 coccinellids per plant were found in chilli border and barrier cropped with south African tall maize which was on par with chilli border and barrier cropped with sweet sorghum (1.63 per plant). Analysis of pooled data also revealed similar trend of treatment significance.

Population density of chrysopids as influenced by various treatments is given in Table 2. The population of chrysoperla varied from 1.21 to 1.91 and 1.31 to 1.96 per plant during 2010-11

Table 2: Population of chilli fruit borer, fruit damage percent and natural enemies in chilli border and barrier cropped with different crops.

Treatment	Fruit borer (larva/plant)			Fruit damage (%)			Cocconellids/plant			Chrysopids/plant		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1- Acetamiprid 20 SP @0.3g/l	1.05ab (1.52)	1.03ab (1.51)	1.02b (1.50)	10.61c (19.00)	10.37c (18.72)	10.49c (18.81)	0.71d (1.34)	0.68d (1.32)	0.70e (1.34)	1.21de (1.60)	1.18cd (1.59)	1.20de (1.60)
T_2- Thiamethoxam 25 WG @1g/l	1.19a (1.59)	1.15a (1.57)	1.16a (1.58)	10.81c (19.19)	10.52c (18.91)	10.67c (19.00)	0.65d (1.31)	0.63d (1.29)	0.64e (1.30)	1.24d (1.61)	1.21c (1.60)	1.23d (1.61)
T_3- Thiacloprid 480 SC @ 1ml/l	0.97b (1.48)	0.95b (1.47)	0.97bc (1.48)	11.85b (20.09)	11.48b (19.73)	11.67b (19.91)	0.82c (1.41)	0.79cd (1.39)	0.81d (1.40)	1.26d (1.62)	1.22c (1.60)	1.24d (1.61)
T_4- Abamectin 1.8 EC @ 0.5ml/l	0.92c (1.46)	0.90bc (1.45)	0.89c (1.44)	11.12bc (19.46)	10.79c (19.09)	10.96bc (19.28)	0.98b (1.49)	0.95b (1.47)	0.97b (1.48)	1.78a (1.83)	1.72a (1.81)	1.75a (1.82)
T_5- NSKE 5% @ 50ml/l	0.74d (1.36)	0.69d (1.33)	0.72d (1.35)	8.89de (17.26)	8.61d (17.05)	8.75e (17.16)	1.12a (1.56)	1.10a (1.55)	1.11a (1.55)	1.82a (1.85)	1.78a (1.83)	1.80a (1.84)
T_6- Diafenthiuron 50 WP @0.75g/l	0.58e (1.26)	0.53e (1.23)	0.56e (1.25)	8.64e (17.05)	8.27de (16.64)	8.46e (16.85)	0.82c (1.41)	0.79cd (1.39)	0.81d (1.40)	1.19de (1.59)	1.15d (1.57)	1.17de (1.58)
T_7- Buprofezin 10 EC @ 0.75ml/l	0.97b (1.48)	0.92b (1.46)	0.95bc (1.47)	12.62a (20.79)	12.32b (20.53)	12.47ab (20.65)	0.87bc (1.43)	0.84c (1.42)	0.86cd (1.43)	1.27d (1.63)	1.23c (1.61)	1.25d (1.62)
T_8- Novaluron 10 EC @ 0.75ml/l	0.29f (1.04)	0.27f (1.02)	0.28g (1.03)	6.52f (14.77)	6.24f (14.42)	6.38g (14.54)	0.93b (1.46)	0.90bc (1.45)	0.92c (1.46)	1.36c (1.67)	1.31c (1.64)	1.34d (1.66)
T_9- Emamectin benzoate 5 SG @ 0.4g/l	0.30f (1.05)	0.28f (1.03)	0.29g (1.04)	6.94f (15.23)	6.79f (15.00)	6.87fg (15.12)	1.08a (1.54)	1.01ab (1.40)	1.05ab (1.52)	1.42c (1.69)	1.39b (1.68)	1.41c (1.69)
T_{10}- Spinosad 45 SC @ 0.3ml/l	0.32f (1.07)	0.29f (1.04)	0.31g (1.06)	7.11ef (15.45)	7.02e (15.34)	7.07f (15.34)	1.14a (1.57)	1.11a (1.55)	1.13a (1.56)	1.39c (1.68)	1.35c (1.66)	1.37cd (1.67)
T_{11}- Imidacloprid 17.8 SL @ 0.3ml/l	1.12a (1.56)	1.08a (1.54)	1.11a (1.55)	12.86a (20.96)	13.42a (21.47)	12.69a (20.79)	0.86c (1.43)	0.82c (1.41)	0.84d (1.42)	1.11e (1.55)	1.04d (1.52)	1.08e (1.54)
T_{12}- Propargite 57 EC @ 2.5ml/l	1.05ab (1.52)	0.98b (1.50)	1.02b (1.51)	13.63a (21.64)	12.51a (20.70)	13.53a (21.56)	0.43e (1.16)	0.40e (1.13)	0.42f (1.15)	1.02e (1.51)	0.96e (1.48)	0.99e (1.49)
T_{12}- Profenofos 50 EC @ 2ml/l	0.36f (1.10)	0.33f (1.07)	0.35fg (1.09)	7.23f (15.56)	7.06e (15.34)	7.15f (15.45)	0.31e (1.06)	0.26e (1.01)	0.29g (1.04)	0.62f (1.29)	0.58ab (1.26)	0.60f (1.27)
T_{14}- Garlic Chilli Kerosene Extract 0.5% @ 5ml/l	0.45e (1.17)	0.41ef (1.14)	0.43f (1.16)	9.24d (17.66)	8.91d (17.36)	9.08d (17.46)	0.96b (1.48)	0.91b (1.45)	0.94b (1.47)	1.67b (1.79)	1.63a (1.78)	1.65b (1.78)
T_{15}- Untreated check	1.17a (1.58)	1.13a (1.56)	1.14a (1.57)	12.76a (20.88)	13.28a (21.28)	13.02a (21.08)	1.17a (1.59)	1.13a (1.56)	1.15a (1.58)	1.86a (1.89)	1.81a (1.85)	1.84a (1.86)
CV	7.56	8.41	6.93	6.71	5.91	6.31	6.56	6.04	5.21	5.34	9.40	5.63
S. Em±	0.04	0.04	0.03	0.41	0.35	0.38	0.04	0.03	0.02	0.04	0.07	0.04
C.D. at 5%	0.12	0.12	0.09	1.19	1.03	1.11	0.11	0.08	0.06	0.12	0.21	0.12

Figures in parenthesis are arc sine transformed values
In a column means followed by the same alphabet did not differ significantly by DMRT (0.05)

and 2011-12, respectively. During both the years, significantly more number of chrysoperla was noticed in chilli border and barrier cropped with sweet sorghum (1.91 and 1.96) compared to rest of the treatments. Pooled data also revealed similar pattern of treatment effects on chrysoperla activity in the crop ecosystem.

Plant height (cm)

The result on plant height at 90 DAT were significant indicating the effect of border and barrier cropping with different crops (Table 3). During 2010-11, it ranged from 52.30 to 76.30 cm, and significantly highest plant height (76.30) was registered in chilli with border and barrier crop of with South African tall maize and was on par with chilli border and barrier cropped with sweet sorghum and chilli border cropped with south African tall maize which registered 75.30 and 65.20 cm, respectively. Treatments chilli border cropped with sweet sorghum, chilli barrier cropping with south African tall maize and chilli barrier cropped with sweet sorghum were the other ones which recorded moderate plant height of 62.50, 61.60 and 59.80 cm, respectively. Sole chilli plot put forth lowest plant height of 52.30 cm.

During 2011-12, plant height was relatively higher compared to previous year. However, consistent trend like previous year was evidenced with plant height ranging from 55.50 to 79.20 cm. Again the treatment chilli border and barrier cropping with South African tall maize and chilli border and barrier cropping with sweet sorghum registered significantly highest plant height (79.20 and 77.70 cm) followed by others as in 2010-11. Significantly lowest plant height (55.50 cm) was recorded in sole chilli. Pooled data also revealed similar trend of treatment significance. These

findings provide strong base to conclude that border and barrier crop of maize and sweet sorghum all along chilli contributed significant role in preventing pest dispersal and conserving and enhancing the population of predators throughout the cropping period and thereby reducing pest load on chilli crop. These results are in agreement with the findings of Shivaprasad *et al.* (2011) in chilli who reported that coccinellids and chrysopids were more under maize barriers and spiders under sorghum barrier. Srinivas and Lawande (2002) in onion crop recorded that maize was a good barrier crop in conservation of coccinellid population. Results of Hook and Fererers (2006) and Fererers (2000) indicated that maize was effective barrier crop in conserving the population of predators. Wang *et al.* (1998) reported that maize was a effective barrier crop in conserving the population of coccinellids and chrysopids in soyabean. Results obtained by Idris *et al.* (1999), Mohammed Rof and Ho (1991) reported that maize was effective barrier crop not only reducing the pest load but also was helpful in conserving the population of coccinellids in chilli ecosystem. Lekshmi *et al.* (2011) evaluated occurrence of natural enemies in organic farming in brinjal. The activity of insect predators was maximum (coccinellids and spiders) in treatment comprising of brinjal barrier cropped with baby corn along with shoot clipping and foliar application of neemol @ 5ml/lit.

Yield (q/ha)

During 2010-11, significantly higher dry chilli yield (4.01 q/ha) was registered in the treatment chilli border and barrier cropped with South African tall maize (T4) and was on par with chilli border and barrier cropping with sweet sorghum (T7) (3.88 q/ha). While others were next in the order of T2 > T5 > T6. However, significantly less dry chilli yield (1.86 q/ha) was recorded in sole chilli and was followed by T3 (2.82) (Table 4). During 2011-12, yields recorded in different treatments were relatively less as compared to previous year, but the same treatment, T4-chilli border and barrier cropped with South African tall maize was found to be most superior by recording highest yield of 3.87 q/ha and was on par with T7 (3.84 q/ha). All treatments were found to be superior over control, in yields realized. Pooled data also revealed similar trend of treatment significance and from the point of yield, the treatments were of the order T4 > T7 > T2 > T5 > T3 > T6 > T1.

Among the different treatments (Table 3) highest net returns (Rs. 19,528/-) was recorded in T4-chilli border and barrier cropped with South African tall maize with C:B ratio of 1: 2.56 followed by chilli border and barrier cropped with Sweet sorghum (Rs. 18,047/- and C:B ration of 1: 2.41), chilli border cropping with south African tall maize (Rs. 11,837/-) and chilli barrier cropped with south African tall maize (10,511/-). Whereas, sole chilli plot recorded net returns of Rs. 3654/- only with C:B ratio of 1:1.32. Shivaprasad *et al.* (2010) reported that dry chilli yield increased to the extent of 150 and 120 percent in the leeward and windward sides of the barrier, respectively over the crop without barriers. Deol and Ratawal (1978) at Ludhiana, reported pearlmillet (Pennisetum typhoides stapf & hubb.), sorghum (*Sorghum bicolor* L.), sesame (*Sesamum indicum* L.) and sunflower (Helianths annuus L.) as the promising barrier crops (1133, 763 and 688 kg ha-1dry fruit yield, respectively) for kharif chilli against cucumber mosaic virus compared to chilli without barrier crop (475 kg/ha). Anandam and Doraiswamy (2007) observed that chilli mosaic disease caused by virus and aphids as carriers could be effectively controlled by barrier crops viz., maize, sorghum and sunflower. Whether chilli sprayed with insecticides or not, barrier crops significantly reduced the disease spread and increased the yield over control. Among all the treatments tried, maize as a barrier crop with insecticidal sprays to chilli performed better and was most effective in reducing the disease spread and increasing yield. By considering different parameters, the treatments viz., chilli border and barrier cropped with South African

Table 3: Effect of different border and barrier crops on chilli plant height, dry chilli yield and cost economics.

Treatments	Dry chilli yield (q/ha)			Gross Returns (`/ha)	Total cost of production (`/ha)	Net Returns (`/ha)	C:B ratio
	2010-11	2011-12	Pooled				
T_1- Acetamiprid 20 SP @0.3g/l	3.42cd	3.00e	3.21d	26322	13788	12534	1: 1.91
T_2- Thiamethoxam 25 WG @1g/l	3.65c	3.85c	3.75c	38130	15469	22661	1: 2.46
T_3- Thiacloprid 480 SC @ 1ml/l	3.28d	3.68c	3.48d	28536	14359	14177	1: 1.98
T_4- Abamectin 1.8 EC @ 0.5ml/l	3.91b	4.12b	3.83c	31406	14485	16921	1: 2.17
T_5- NSKE 5% @ 50ml/l	2.58e	2.50f	2.54f	20828	12169	8659	1: 1.71
T_6- Diafenthiuron 50 WP @0.75g/l	4.55a	4.75a	4.65a	38130	14835	23295	1: 2.57
T_7- Buprofezin 10 EC @ 0.75ml/l	4.58a	4.40a	4.49a	36818	15372	21446	1: 2.40
T_8- Novaluron 10 EC @ 0.75ml/l	4.00b	4.24b	4.12b	33784	15618	18166	1: 2.16
T_9- Emamectin benzoate 5 SG @ 0.4g/l	4.76a	4.25b	4.51a	36982	16685	20277	1: 2.22
T_{10}- Spinosad 45 SC @ 0.3ml/l	4.50a	4.64a	4.57a	37474	17165	20309	1: 2.18
T_{11}- Imidacloprid 17.8 SL @ 0.3ml/l	3.51cd	3.61c	3.56d	29192	14458	14734	1: 2.02
T_{12}- Propargite 57 EC @ 2.5ml/l	3.00d	3.28d	3.14d	25748	12975	12773	1: 1.98
T_{12}- Profenofos 50 EC @ 2ml/l	3.03d	2.83e	2.93e	24026	12469	11557	1: 1.93
T_{14}- Garlic Chilli Kerosene Extract 0.5% @ 5ml/l	2.74e	2.54f	2.64f	21648	12378	9270	1: 1.75
T_{15}- Untreated check	2.12e	2.03e	2.07e	16,974	11341	5633	1: 1.49
CV	6.78	7.02	6.38				
S. Em±	0.15	0.17	0.09				
C.D. at 5%	0.41	0.42	0.32				

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Market price: Chilli – Rs. 8200/q

tall maize and with sweet sorghum were found promising against chilli pests.

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Time Scale Changes in Abundance Pattern of Mesozooplankton with Special Reference to Calanoid Copepods in Cochin Estuary

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ABSTRACT

Zooplankton plays an important role providing the energy at the secondary level in the pelagic food chain of an aquatic ecosystem. Coastal ecosystems due to human influence have been altered affecting its productivity leading to changes in the trophic dynamics and carbon assimilation and transfer efficiency of the systems. The diversity and abundance of mesozooplankton from nine stations in Cochin estuary was investigated seasonally during 2013. Twenty five functional groups of zooplankton including seventeen groups of holoplankton and eight groups of meroplankton were encountered of which, the copepods constituted the most dominant group (53%) followed by crustacean nauplii (15%), zoea (8%) and mysids (5%) etc. Twenty two calanoid copepod species belonging to ten genera and six families were identified during the study period where Family Acartiidae was dominant that contributed 37% of total calanoid copepod followed by Paracalanidae (25%) and Pseudodiaptomidae (21%). Highest value of diversity index (Shannon Weiner diversity index-H') for both zooplankton and copepod were recorded in station 5 (2.309) and station 7 (2.378) in pre-monsoon season respectively. Seasonal and diel variations in physico-chemical parameters resulted in highly unstable condition influencing the composition and diversity of zooplankton in the estuary. BEST analysis showed that silicate, nitrate, dissolved oxygen and chlorophyll '*a*' determined the distribution of mesozooplankton whereas the copepods were influenced by phosphate, ammonia, dissolved oxygen, water temperature and salinity in the estuary. Even though seasonal and diel variations influenced the physico-chemical features of the estuary causing highly unstable conditions, that was reflected in the composition and diversity of the zooplankton in the estuary. The physico-chemical characteristics prevailing in the estuary as well as the intense sampling procedures adopted during the study could have possibly favoured an improved composition and abundance of mesozooplankton in Cochin estuary as compared to earlier works.

Key words: Mesozooplankton, Calanoid copepods, Diversity, Cochin estuary.

INTRODUCTION

Estuaries are dynamic ecosystems undergoing considerable variations in the physico-chemical characteristics due to the mixing of sea water and freshwater. Zooplankton plays an important role in the pelagic food chain often being an important predator regulating the top down energy transfer in the aquatic ecosystem. The distribution of zooplankton in Indian estuaries has been studied by several researchers (Nagarajaiah and Gupta, 1985: Sreenivasan and Santhanam, 1991: Karuppasamy and Perumal, 2000: Patil *et al.*, 2002: Qasim 2005). The seasonal changes in zooplankton population in Cochin estuary (Wellershaus, 1974); Ashtamudi

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Estuary (Divakaran *et al.*, 1982); Edava-Nadayara-Paravur Backwaters (Abdul Azis, 1978); (Abdul Azis and Nair, 1982) and Veli Lake (Arunachalam et al., 1982); and Vembanad Lake (Haridevi *et al.*, 2004) were also reported. The seasonal and spatial distribution of zooplankton in the retting zones of Kadinamkulam estuary was also studied by Bijoy Nandan and Abdul Azis (1994). Cochin estuary is facing severe ecological problems due to reclamation of land for urbanization, industrialization leading to eutrophication (Gopalan *et al.*, 1983) as a result, the population and structure of trophic food webs has been altered affecting the overall functioning of the ecosystems (Unnithan *et al.*, 1975).This contribution attempts to present the abundance pattern and diversity of mesozooplankton on a time scale basis in relation to the physio-chemical characteristics.

MATERIALS AND METHODS

Cochin estuary forms a complex, shallow estuarine network (250km^2) running parallel to the coastline of Kerala extending 9° 40' and 10° 12'N and 76° 10' and 76° 30'E with its northern boundary at Azheekode and southern boundary at Thanneermukkam bund. It has a length of 80 km and the width varies between 500 and 4000 m with an average depth that ranges from 2–7 m upto the Thanneermukkam bund. The estuary forms a major part of the Vembanad backwater system, a Ramsar site on the south west coast of India. Six rivers discharge freshwater into this estuarine system, the Periyar in the north; Pampa, Achankovil, Manimala, and Meenachil in the south; Muvattupuzha, midway between the two (Sreenivasan *et al.*, 2000) and connected to the Arabian Sea at Cochin gut and another at Azheekode. Three seasonal conditions mainly prevail in the estuary, the monsoon (June-September), post monsoon (October-January) and pre monsoon (February-March). Monsoon period is characterized by heavy rain fall resulting from south west monsoon rains with high river discharge and low salinity. Post monsoon is characterized by north east monsoon showers with a gradual rise in salinity considered as a transitional period. In pre - monsoon period, surface waters was characterized by high salinity with that of inshore waters of Arabian Sea. Nine different stations from Cochin estuary were selected for the collection of mesozooplankton during March (Pre-monsoon), July (Monsoon), and December (Post Monsoon) 2013 periods (Fig.1). The sampling locations were fixed by Global Positioning System (GPS) (Magellan® Triton 200/300).

Sampling and analysis

The sub surface water samples were collected using Niskin water sampler (General Oceanics-5L) were kept in icebox and brought to the laboratory. Dissolved oxygen concentration was estimated by modified Winkler's titration method (Strickland and Parsons, 1972). For the estimation of chlorophyll '*a*', water samples were filtered immediately after collection and estimated based on standard procedure (APHA, 2005). The inorganic nutrients, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, phosphate-phosphorus and silicate-silicon samples were acidified with conc.HNO_3 and analyzed based on standard methods where N: P ratio was calculated by Redfield ratio (Grasshoff *et al.*, 1999: Redfield, 1958). The mesozooplankton samples were collected using a bongo net (200μm mesh size) with a mouth area 0.28m^2. A calibrated flow meter (General Oceanics model number-2030 R, 2012) was attached to the net and towed horizontally just below the surface with a fixed speed of ~ 1 knot for the duration of 10 - 15minutes. The samples were then preserved in 4% buffered formalin (0.5g sodium borate and 6.5g disodium hydrogen phosphate/L). Zooplankton biomass was estimated by displacement volume method and expressed as ml / m^3 (Harris *et al.*, 2003: Jhonson and Allen, 2005). Samples were sorted at group level for the major zooplankton taxa (Omori

and Ikeda, 1984: Tait, 1981: Todd and Laverack, 1991) and enumerated and density was expressed in ind./m^3. From the samples calanoid copepods were sorted out and identified to the lowest possible taxa using standard keys (Sewell and Seymour, 1947: Kasturirengn, 1963: Wellershaus, 1969). Zooplankton group abundance was constructed on the basis of Bray Curtis similarity and Non-metric Multi-dimensional Scaling (MDS); diversity indices like, Shannon Weiner diversity index(H'), Margalef's richness (d), Pielou's eveness (J'), Simpson's dominance (Lambda) were calculated and environmental match (BEST) also analysed using PRIMER Version 6.1 (Clarke and Gorley, 2006).

RESULT AND DISCUSSION

Physico-chemical characteristics

The physico- chemical characteristics of Cochin estuary is presented in Table 1. The mean depth of Cochin estuary was 2.98 m. Cochin estuary was characterized with warm waters (27.4±1.23^{0}C) and saline waters (27.3±1.68 psu) in pre-monsoon season. Mean temperature varied from 20.6 ±0.71 to 27.4±1.23^{0}C and salinity from 4.56±3.09 to 27.3±1.68 psu. Dissolved oxygen in the surface waters varied from 5.51±0.65 to 7.6±0.42 mg/l where higher values of dissolved oxygen were found during monsoon season (7.6±0.42 mg/l). The higher oxygen concentration during this period could be due to the higher primary production occurring in the surface layers during monsoon season (Anirudhan, 1987). Nitrate-nitrogen in water ranged from 0.25±0.053 to 2.49±0.27 μmol/l and was higher in estuarine zone due to freshwater input from the rivers. Nitrite-nitrogen varied from 0.38±0.14 to 0.71±0.37 μmol/l whereas average ammonia-nitrogen concentration ranged from 2.66±1.58 to 22.43±7.32μmol/l. Surface water showed maximum ammonia-nitrogen concentration during pre-monsoon period (22.43±7.32 μmol/l) and monsoon period (17.23±18.00 μmol/l). The concentration of ammonia was slightly higher compared to nitrate and nitrite values. The phosphate-phosphorus concentration in water varied from 0.53±0.32 to 4.38±1.83 μmol/l that of silicate content varied from 24.92±9.38 to 127.9±22.9 μmol/l. The constant nutrient supply in an estuary supports rich phytoplankton production, but generally nitrogen (N) and phosphorus (P) have been considered as the limiting nutrients for phytoplankton growth (EEA, 1999: Neil 2005) which in turn attribute to zooplankton growth. Phosphorus is being attributed as limiting nutrient in the fresh waters, whereas nitrogen is being attributed in the coastal waters (Fisher and Peele, 1992: Neil, 2005). The mean N: P (nitrogen: phosphorus) ratio of Cochin estuary was found to be 8.65±1.85 with the highest value during pre-monsoon season (10.73±9.48) and lowest during monsoon season (7.2±6.61). The concentration of nitrate, nitrite, phosphate and silicate showed prominent seasonal variation and also indicated inputs from industrial units, sewage waste and agricultural run offs (Lakshmanan *et al.*, 1987). A comparison of the nutrient distribution with earlier reports suggests that the resultant activities could be linked to inter basin transfer of water and the construction of Thanneer-mukkam bund (Joseph, 1974: Manikoth and Salih, 1974). Later, studies by Anon have revealed the source of inputs and hydrodynamic control on commissioning of the Thanneermukkam water barrier at Alappuzha (Anon, 1989). Mean chlorophyll a concentration showed major seasonal variation and the values ranged between 7.75±3.24 to 22.4 ±0.62mg/m^3 with the lowest value during monsoon and the highest value during pre-monsoon.

Table 1: Seasonal average of physico chemical characteristics in Cochin estuary during the study period.

Parameter	Pre monsoon	Monsoon	Post Monsoon
Water temperature (^{0}C)	27.4 ± 1.23	20.6±0.71	25.4±1.07
Salinity (psu)	27.3±1.68	4.56±3.09	26.10±3.57
Dissolved oxygen(mg/l)	5.51±0.65	7.6±0.42	6.51±0.15
Nitrate-nitrogen (μmol/l)	2.49±0.27	0.78±0.27	0.25±0.053
Nitrite-nitrogen (μmol/l)	0.71±0.37	0.59±0.26	0.38±0.14
Ammonia-nitrogen (μmol/l)	22.43±7.32	17.23±18.00	2.66±1.58
Phosphate-phosphorus (μmol/l)	4.38±1.83	2.63±1.00	0.53±0.32
Silicate- silicon (μmol/l)	29.82±10.56	127.9±22.9	24.92±9.38
Chlorophyll a (mg/m^3)	22.4 ±0.62	7.75±3.24	13.02±5.14

Composition and Abundance of Mesozooplankton and Copepods

The mean abundance and percentage composition of the major functional groups of zooplankton in Cochin estuary are shown in Table 2. The average mesozooplankton biomass recorded in the estuary was 5.09 ml/m^3. The highest density of zooplankton was recorded in pre-monsoon season (84825 ind./m^3) and the lowest in monsoon season (20775 ind./m^3). In pre-monsoon season, the entire water column showed stable and uniform hydrographic conditions and the estuary becomes almost an extension of the adjacent sea with higher salinity and temperature values. Earlier studies in the same estuary have shown that zooplankton numbers and species diversity are higher in pre-monsoon season than SW monsoon season, which indicates that was the main factor controlling the distribution of zooplankton community (Madhu *et al.*, 2007). Zooplankton abundance in pre-monsoon season was also reported from Panangad region, Vembanad Lake, Pichavaram mangroves and Pullavazhi backwaters (Haridevi *et al.*, 2004: Karuppasammy and Perumal, 2000: Sreenivasan and Santhanam, 1991). Seasonal changes of plankton in Cochin estuary was also reported by several authors (George, 1958: Nair and Tranter, 1969).

In Cochin estuary, mesozooplankton mainly consisted of estuarine, marine and freshwater forms which are volumetrically abundant but limited in species composition. It was represented by a total of 25 functional groups of organisms including 17 groups of holoplankton and 8 groups of meroplankton in the total zooplankton population. Holoplankton was dominated throughout the period; contributing 64% of total zooplankton and 36% of them were represented by meroplankton. Copepod was the major functional group contributing 53% of total zooplankton followed by nauplii (15%), zoea (8%) mysids (5%) and also groups like fish larvae (3%), molluscan larvae (2.6%), cypris larvae (1%) contributing in minor proportions. A well distinct seasonal variation was observed in the mesozooplankton diversity during the present study. In pre-monsoon season, 45% of plankton biomass was contributed by copepod followed by zoea (21.3%), nauplii (11.8%) and mysidacea (11.7%). Calanoids, nauplii, mysids and fish larvae were observed in all stations. In monsoon season, copepods contributed, 73.2% of total zooplankton population, in which nauplii and

mysids were replaced by cladocera (7.2%) and molluscan larvae (5.8%), followed by zoea (2.3%), rotifera (1.8%) and mysids (1.6%). Calanoids, cyclopoids, mysids, molluscan larvae and cladocera were observed from all stations during this period. In post monsoon, copepods contributed 36.7 % followed by nauplii (33%), copepodites (13.8%), cyclopoids (4.4%), and cumaceans (1.9%) respectively. Here, calanoids, cyclopoids, copepod nauplii and cumaceans were observed from all stations. During this study, copepods were uniformly distributed throughout the study area where jelly fish represented 1% of total mesozoo-plankton population and was confined to Fort Kochi bar mouth in pre-monsoon season, indicating the presence of high saline water in Fort Kochi bar mouth area.

Cochin estuary supports diverse species of flora and fauna according to their tolerance for saline environments. The salinity variation in Cochin estuary is mainly affected by tidal influence (Qasim and Gopinathan, 1969). The higher temperature and uniformly high salinity throughout the estuary permits the migration of a large number of marine species to the northern part of the estuary. The incursion of marine fauna into estuary is obvious during pre-monsoon season with high surface salinity but in the monsoon season many of the organisms were observed to disappear from the surface layers by freshwater intrusion (Madhu *et al.*, 2007). The plankton composition in the estuary has changed over the years. Previous studies in the estuary have revealed striking variation of zooplankton composition within the estuary. A qualitative and quantitative study of plankton enumerated the more common groups and reported the relationship existing between the seasonal changes of the zooplankton population and some of the environmental parameters (George, 1958). During this study, zooplankton density was found to decrease in monsoon and lowest was noticed in S6. A similar observation was made in the same estuary (Nair *et al.*, 1971). In this study 25 functional groups of zooplankton were recorded. A few reports were published representing the amplitude of seasonal and spatial changes of zooplankton in Vembanad Lake and connected backwaters. In an earlier study, thirteen groups of zooplankton and eleven numerically dominant calanoid copepods from Cochin estuary were reported by Pillai and Pillai, (1973). Twenty five groups of zooplankton including adult decapods were also reported by Silas and Pillai, (1975). Sixteen groups of zooplankton were reported from Vembanad Lake (Pillai *et al*, 1975) where, general seasonal fluctuations were observed in zooplankton groups of which jelly fish was observed only in pre-monsoon season (Pillai *et al.*, 1975). In recent studies, ten groups of zooplankton were reported (Madhu et al, 2007) while in a study, rotifers (52%) and copepods (40%) formed the most dominant groups among the 17 groups of zooplankton from Cochin estuary by Molly and Krishnan (2009). More recently, a well-balanced community structure of zooplankton including twenty two groups dominated by copepods, ichthyoplankton (fish eggs, fish larvae), larval forms of crustaceans, polychaetes and tintinnids were reported but suggested that environmental stress in the Cochin estuary has not yet affected the biological productivity of the system (Jose *et al.*, 2010).

The Bray-Curtis MDS plot based on the abundance of mesozooplankton indicates 60% similarity in all seasons where, stations 1, 4, 6- 9 (pre-monsoon) stations 1, 4, 6-9 (monsoon) and stations 2, 3, 5-9 (post-monsoon) showed 80% similarity (Fig.2). Results of the hierarchical cluster analysis of mesozooplankton showed 94.53% similarity in S8 and S9 during the pre-monsoon season (Fig.3). Highest value of diversity index (Shannon Weiner diversity index-H') was recorded in S5 (2.309) followed by

S4 (2.204) and S9 (2.159) in pre-monsoon season. For Pielou's Evenness index (J), the maximum value of 0.8148 was recorded in S5 and a minimum of 0.4943 in S1 in pre-monsoon season. Environmental match BEST analysis showed that silicate, nitrate, dissolved oxygen and chlorophyll a plays a crucial role in controlling the distribution and abundance of mesozooplankton with a correlation coefficient (Rho) of 0.533 (Table 3).

In tropical estuaries, copepods form the major zooplankton component and are important in an estuarine zooplankton community. Their abundance and distribution are mainly influenced by the prevailing hydrographic conditions (Boucher *et al.*, 1987: Hedgpeth, 1957). Even though estuarine habitat is considered to be ecologically severe but species diversity is usually low compared to oceanic realm (Tranter, 1966). In Cochin estuary, a density of ca. 55,000 ind./m^3 of copepods was recorded (Tranter and Abraham, 1971) while an even higher abundance of 286,000 ind./m^3 had been reported from the Vellar estuary (Subbaraju and Krishnamurthy, 1972). Copepods usually dominate in the coastal waters and they are numerically abundant than offshore waters. In the present study, total mean abundance of calanoid copepods varied from 832 ind./m^3 to 3601 ind./m^3 during monsoon and pre-monsoon season (Table 4). Calanoids were the major copepod community followed by cyclopoids and harpacticoids. A total of 22 calanoid copepod species representing 10 genera and 6 families were identified during the period (Table 5).

In the present study, most copepods were represented by typical brackish and marine forms. Visible variation in copepod diversity was observed due to salinity changes in the environment. Cochin estuary was highly saline in pre-monsoon season (27.3±1.68 psu) and *Bestiolina similis* (667 ind/m3) was the most abundant calanoid copepod that represented 19% of total calanoid copepods, followed by *Paracalanus crassirostris* (av.565 ind./m^3) (16%), *Acartia plumosa* (av.440 ind./m^3) (12%) and *Acartia centrura* (av. 386 ind./m^3) (11%). Highest density of *B. similis* was recorded in S6 (1580 ind./m^3) and lowest was in S1 (210 ind./m^3). *Paracalanus crassirostris* is considered as eurythermal and euryhaline species, widely distributed in pre-monsoon season with highest number in S6 (1250 ind./m^3) and lowest in S4 (150 ind./m^3). *Acartia* species was the most common calanoid copepod contributing to the major portion of the copepod population throughout the year. The distribution of *Acartia* species was mainly affected by salinity and temperature where *Acartia plumosa* has been reported in medium saline conditions from the Cochin estuary (Ueda, 1987: Cervetto, 1999: Gaudy, 2000: Haridas, 1982). Eleven species of Family Acartiidae were reported from the Cochin estuary (Abraham, 1969) and co-existence of the species of Acartiidae in Cochin estuary was also revealed Tranter and Abraham (1971). In this investigation, eight species of Family Acartiidae were observed from the study area. They were, *Acartia bilobata, A. centrura, A. erythrae,* A. plumosa, *A. southwelli, A. spinicauda, Acartiella keralensis, and A. gravelyi*. Family Acartiidae and Pseudodiaptomidae were relatively diverse copepods in this estuary in which Acartiidae contributed 47% of total calanoid copepod followed by Paracalanidae (40%), Pontellidae (7%), Centropagidae (4%) and the least by Pseudodiaptomidae (2%). Adult females of *Pseudodiaptomus annandalei* and P. *serricaudatus* were observed with egg sac during the study period. The presence of adult with immature forms of this family suggesting active breeding may takes place in pre-monsoon period. *Centropages furcatus, Acartiella gravelyi and Acartia* species were also noticed with spermatophore indicating that breeding takes place in this estuary.

Monsoon season was characterized by copepodite (16%) and marine forms that were completely replaced by brackish and freshwater

forms (79%). In monsoon season, Family Acartiidae was dominated by 64% followed by Pseudodiaptomidae (16%) and Diaptomidae (4%). *Acartiella gravelyi* (av.470 ind./m^3) (57%) was the most successively distributed copepod in monsoon season along with *Pseudodiaptomus binghami malayalus* (av.57 ind./m^3), *Heliodiaptomus cinctus* (av.25 ind./m^3) and *Allodiaptomus mirabilipes* (av.7 ind. /m^3). These species prefer low salinity and observed in oligo-mesohaline water. Swarming of *Acartiella gravelyi* was also observed with maximum number in S5 (825 ind./m^3) and lowest in S7 (75 ind./m^3). Maximum number of *Acartiella keralensis* was recorded in S9 (38 ind./m^3) and lowest was in S5 (8 ind./m^3). Highest density of a fresh water copepod Heliodiaptomus cinctus was recorded in S1 (75 ind./m^3) whereas lowest was recorded in S5 (15 ind./m^3). *Allodiaptomus mirabilipes* was found only in S1 (30 ind./m^3), S4 (15 ind./m^3) and S9 (15 ind./m^3). In post monsoon, *Pseudodiaptomus serricaudatus* a euryhaline commonly observed inshore plankton (av.1305 ind./m^3) (46%) exclusively dominated the bulk of total calanoid copepods followed by Family Paracalanidae (35%), Centropagidae (2%), Acartiidae (1%) and Pontellidae (1%). Highest density of P. *serricaudatus* was recorded in S1 (3375 ind./m^3) and lowest was in S8 (235 ind./m^3). Irrespective of all seasons, Acartiidae (37%), Paracalanidae (25%) and Pseudodiaptomidae (21%) were the dominant copepod taxa comprising 83% of the total calanoid copepod population in this estuary.

Most of the copepods are opportunistic in their behavior and most of them were disappearing during monsoon season (Madhupratap et al., 1987). The presence of *Acartiella gravelyi, Pseudodiaptomus binghami malayalus, Allodiaptomus mirabilipes* and *Heliodiaptomus cinctus* during the present study indicates their salinity tolerance. The dominance of high saline copepod species such as *Centropages furcatus, C. orisinii, Labidocera pectinata, Paracalanus crassirostris, Acartia centrura* and *A. spinicauda* are indicating their origin from coastal waters. Earlier works by several authors and present investigation show that the calanoid copepods of the Families Pseudodiaptomidae and Acartiidae offer good examples of spatial distribution in relation to different ecological conditions (Pillai et al., 1973). The species association of calanoid copepods from this estuary was analyzed (Madhupratap *et al.*, 1975). The numerical abundance and distribution of total calanoid population off Cochin with remarks on species diversity were also studied and eighteen species of copepods were reported (Stephan and Iyer, 1979: Stephan, 1977).

Highest diversity index (Shannon Weiner diversity index-H') of calanoid copepods was recorded in S7 (2.378) followed by S1 (2.287) and S9 (2.208) in pre-monsoon season. For Pielou's Evenness index (J), the maximum value of 0.8783 was recorded in S7 (pre-monsoon) and a minimum of 0.3426 in S5 (Monsoon).

Hierarchical cluster analysis of calanoid copepods indicates 95.82% similarity for *Bestiolina similis* and *Paracalanus crassirostris* collectively (Fig.4). Environmental match BEST analysis shown that phosphate, ammonia, dissolved oxygen, water temperature and salinity plays a crucial role in controlling the distribution and abundance of copepods in the estuary with a correlation coefficient (Rho) of 0.902 (Table 6).

Table 2: Mean abundance (ind./m^3) and percentage composition of major groups of mesozooplankton in Cochin estuary during the study period.

Zooplankton	Pre-monsoon	Monsoon	Post monsoon
Holoplankton			
Foraminifera	-	-	13 (0.4%)
Rotifera	-	43 (1.8%)	30 (1%)
Medusa	54 (1%)	-	-
Chaetognatha	22 (0.2%)	-	2 (0.1%)
Calanoida	3613 (38.3%)	832 (36%)	1061 (36.7%)
Cyclopoida	615 (6.5%)	859 (37.2%)	126 (4.4%)
Harpacticoida	40 (0.4%)	-	41 (1.4%)
Copepodite	-	-	399 (13.8%)
Lucifera	133 (1.4%)	-	12 (0.4%)
Mysidacea	1099 (11.7%)	36 (1.6%)	17 (0.6%)
Cladocera	8 (0.1%)	166 (7.2%)	-
Amphipoda	1	-	5 (0.2%)
Cumaceans	-	-	54 (1.9%)
Aquatic insects	-	6 (0.3%)	-
Water mites	-	3 (0.1%)	-
Arachanidae	-	3 (0.1%)	-
Oikopleura	-	-	15 (0.5%)
Meroplankton			
Mysis	108 (1.1%)	3 (0.1%)	35 (1.2%)
Zoea	2010 (21.3%)	53 (2.3%)	15 (0.5%)
Nauplius	1116 (11.8%)	7 (0.3%)	955 (33%)
Polychaete larvae	47 (0.5%)	-	8 (0.35%)
Molluscan larvae	81 (0.9%)	134 (5.8%)	43 (1.5%)
Cypris larvae	271 (2.9%)	-	12 (0.4%)
Fish egg	83 (0.9%)	3 (0.1%)	32 (1.1%)
Fish larvae	126 (1.3%)	163 (7.1%)	19 (0.7%)

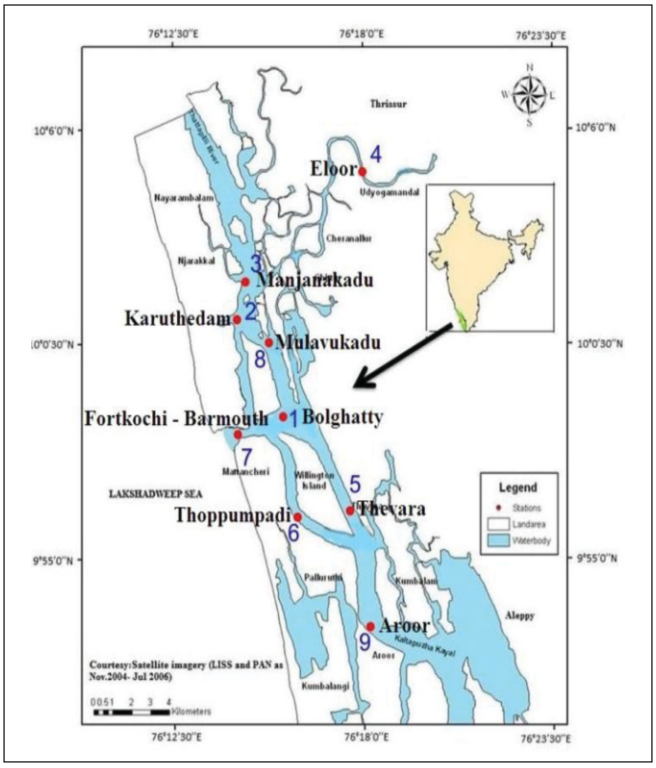

Fig. 1: Map of Cochin estuary indicating the study sites.

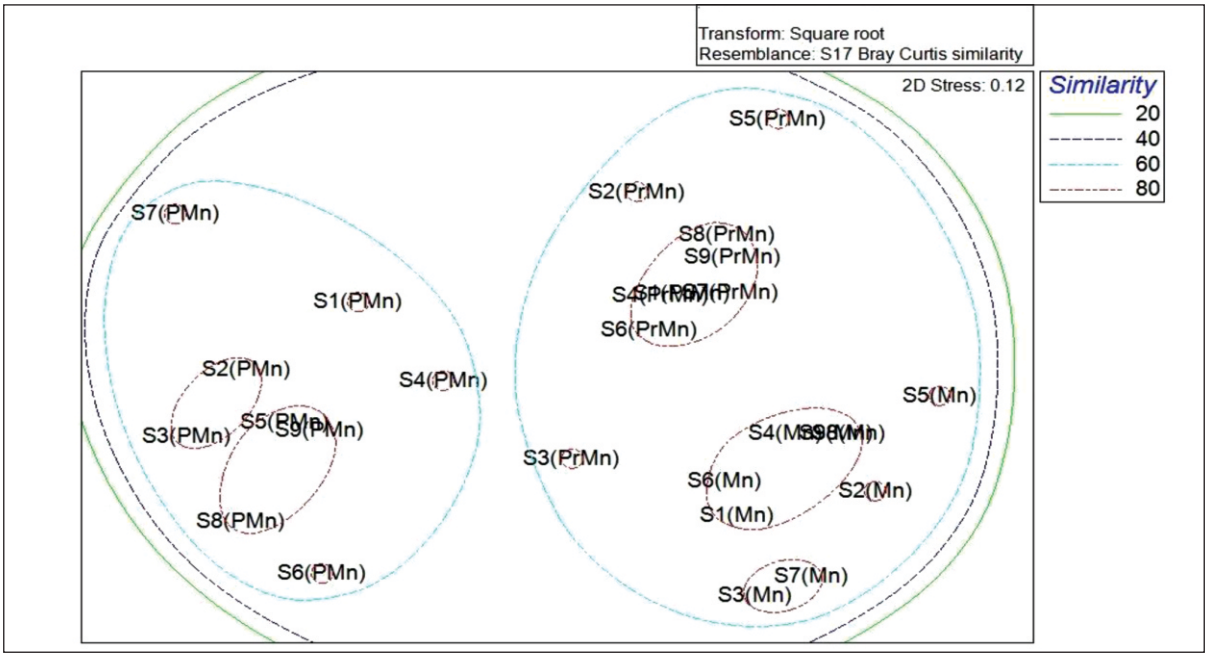

Figure 2: Non-metric Multi-Dimensional Scaling of mesozooplankton in Cochin estuary during the study period.

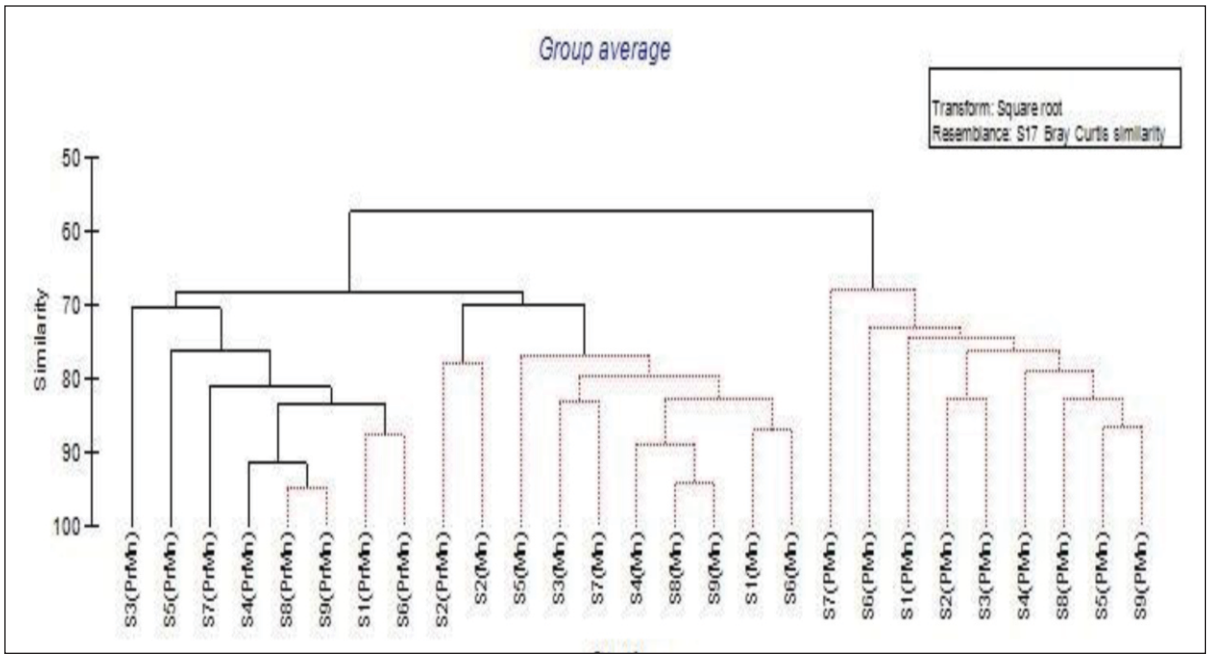

Figure 3: Hierarchical cluster analysis of the mesozooplankton during in Cochin estuary during the study period.

Table 3: Table showing the BEST results of mesozooplankton abundance (Rho=0.533) in Cochin estuary during the study period.

No. of variables	Correlation co-efficient(Rho)	Variables
4	0.533	Silicate, nitrate, dissolved oxygen and chlorophyll α
5	0.529	Silicate, ammonia, nitrate, dissolved oxygen and chlorophyll α
4	0.510	Nitrate, dissolved oxygen, salinity and chlorophyll α
3	0.509	Nitrate, dissolved oxygen and chlorophyll α
4	0.508	Silicate, ammonia, dissolved oxygen and chlorophyll α
3	0.507	Silicate, dissolved oxygen and chlorophyll α
5	0.507	Silicate, nitrate, dissolved oxygen, salinity and chlorophyll α

Table 4: Variation in mean abundance (ind./m^3) of Calanoid copepod species in Cochin estuary during the study period.

No.	Calanoids	Pre-monsoon	Monsoon	Post monsoon
1	*Acartia bilobata*	76	0	0
2	*Acartia centrura*	386	1	9
3	*Acartia erythraea*	228	0	0

4	*Acartia plumosa*	440	23	14
5	*Acartia spinicauda*	375	1	0
6	*Acartia southwelli*	193	23	6
7	*Acartiella gravelyi*	0	470	0
8	*Acartiella keralensis*	0	14	0
9	*Centropages furcatus*	163	0	37
10	*Centropages orisinii*	80	0	26
11	*Allodiaptomus mirabilipes*	0	7	0
12	*Heliodiaptomus cinctus*	0	25	0
13	*Acrocalanus longicornis*	0	0	290
14	*Bestiolina similis*	667	1	456
15	*Paracalanus crassirostris cochinensis*	565	0	216
16	*Paracalanus indicus*	182	0	26
17	*Labidocera pectinata*	160	0	43
18	*Pseudodiaptomus annandalei*	45	77	0
19	*Pseudodiaptomus aurivilli*	0	1	0
20	*Pseudodiaptomus binghami malayalus*	0	57	0
21	*Pseudodiaptomus mertoni*	9	1	0
22	*Pseudodiaptomus serricaudatus*	31	0	1305
	Total	3601	832	2894

Table 5: Calanoid copepod species recorded in Cochin estuary during the study period.

Calanoida Sars, 1902	**Taxa**	**PrMn**	**Mn**	**PMn**
Family Acartiidae Genus Acartia	*Acartia bilobata* Abraham, 1970	+	-	-
	Acartia centrura Giesbrecht, 1889	++	+	+
	Acartia erythraea Giesbrecht, 1889	+	-	-
	Acartia plumosa T.Scott, 1894	++	+	+
	Acartia spinicauda Giesbrecht, 1889	++	+	+
	Acartia southwelli Sewell, 1914	+	+	+
	Acartiella gravelyi Sewell, 1919	-	+++	-
	Acartiella keralensis Wellershaus, 1969	-	+	-
Family Centropagidae Genus Centropages	*Centropages furcatus* Dana, 1849	+	-	+
	Centropages orisinii Giesbrecht, 1889	+	-	+
Family Diaptomidae Genus Alliodiaptomus	*Allodiaptomus mirabilipes* Kiefer 1936	-	++	-
Genus Heliodiaptomus	*Heliodiaptomus cinctus* Gurney, 1907	-	++	-

Family Paracalanidae Genus Acrocalanus	*Acrocalanus longicornis* Giesbrecht, 1889	-	-	++
Genus Bestiolina	*Bestiolina similis* Sewell, 1914	+++	+	+++
Genus Paracalanus	*Paracalanus crassirostris* cochinensis Wellershaus, 1969	+++	-	+
	Paracalanus indicus Wolfenden, 1905	+	-	+
Family Pontellidae Genus Labidocera	*Labidocera pectinata* Thompson I.C. & Scott A., 1903	+	-	+
Family Psuedodiaptomidae				
Genus Pseuododiaptomus	*Pseudodiaptomus annandalei* Sewell, 1919	+	++	-
	Pseudodiaptomus aurivilli Cleve, 1901	-	+	-
	Pseudodiaptomus binghami malayalus Wellershaus, 1969	-	++	-
	Pseudodiaptomus mertoni Früchtl, 1924	+	+	-
	Pseudodiaptomus serricaudatus Scott T., 1894	+	-	+++

"+" denotes presence, "++" denotes less abundant, "+++" denotes Abundant "-" denotes absence; "PrMn", "Mn", "PMn" denotes Pre-monsoon, Monsoon and Post monsoon respectively

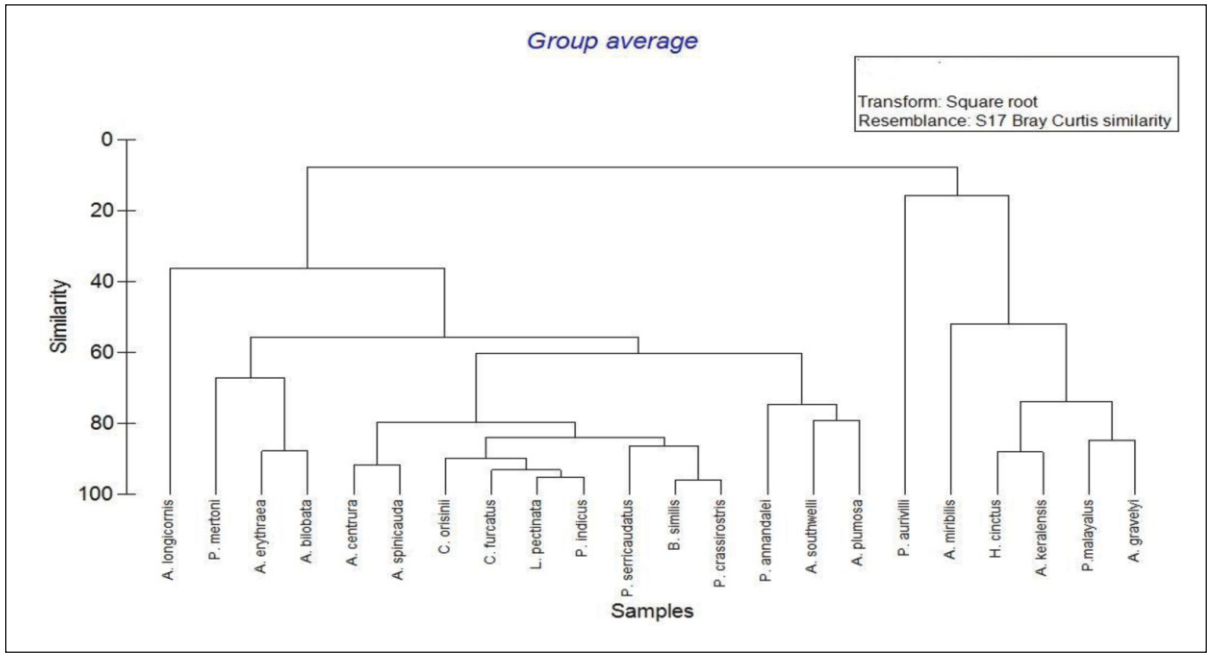

Fig. 4: Hierarchical cluster analysis of the calanoid copepods in Cochin estuary during the study period.

Table 6: Table showing the BEST results of copepod abundance (Rho=0.902) in Cochin estuary during the study period.

No. of variables	Correlation co-efficient(Rho)	Variables
5	0.902	Phosphate, ammonia, dissolved oxygen, water temperature and salinity
5	0.898	Silicate, phosphate, ammonia, dissolved oxygen, water temperature and salinity
5	0.896	Silicate, ammonia, dissolved oxygen, salinity and chlorophyll a
5	0.895	Ammonia, dissolved oxygen, water temperature, salinity and chlorophyll a
5	0.891	Ammonia, nitrate, dissolved oxygen, water temperature and salinity
5	0.889	Silicate, ammonia, nitrate, dissolved oxygen and salinity
5	0.884	Silicate, phosphate, nitrate, dissolved oxygen and salinity

CONCLUSIONS

Time scale changes in abundance pattern of mesozooplankton from Cochin estuary is presented in this study. Twenty five functional groups of mesozooplankton including 22 calanoid copepods were observed from the study. The study reveals that there is an increasing trend for zooplankton assemblage in the estuarine system compared to the previous studies. Even though seasonal and diel variations are influencing the physico-chemical features of Cochin estuary leading to unstable conditions that is reflected the composition and diversity of the zooplankton. But, previous literature revealed that environmental stress such as land reclamation, eutrophication and dredging activities and possible inflow of pollutants in the Cochin estuary has had a marginal effect on the zooplankton composition and abundance in the estuary.

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International Journal on Environmental Sciences **6** (2) : 196-204, July_December 2015 **Research Article**
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Study of Suspended Particulate Matters (SPM) on Optical Characteristics of Potato (*Solanum tuberosum* L.) Genotypes Sown at Variable Weather Condition

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ABSTRACT

A field experiment was conducted during Rabi season 2013 and 2014 at Industrial area Jagdishpur (Amethi) and non-industrial area Kumarganj (Faizabad) of Uttar Pradesh. Three varieties of potato namely, Kufri Chandramukhi, Kufri Bahar, Kufri Anand were sown in sandy loam soil at three dates of sowing viz., 15th October, 1st November, 15th November in split plot design with four replications. Average Air Quality Index (AQI) of both the experimental site resulted that AQI values varied from clean air (0–25) at non-industrial to Moderate air pollution (51-75) at industrial area. On the basis of the AQI scale, it was found that the atmospheric environment of industrial area is moderately polluted to unhealthy range. Optical characteristic of solar radiation was determined at 30, 45, 60, 75, 90, 105 and 115 days after sowing (DAS) with the help of Lux meter. It was concluded that maximum absorption of solar radiation was at 75 DAS sown on 15th November in both industrial and non-industrial area with the existing minimum concentration of SPM (190$\mu g/m^3$) at industrial area and (17.5 $\mu g/m^3$) in non-industrial area. The absorbed radiation indicated that maximum absorption of solar radiation from the crop canopy at sowing on 15th November at 75 DAS in industrial and non-industrial sites was maximum. This ultimately resulted the maximum absorption of photosynthetic radiation hence more chlorophyll and better radiation use efficiency.

Key words: Suspended Particulate matters, Optical characteristics and Air quality index.

INTRODUCTION

Suspended particulate matter as a complex mixture of elemental carbon (EC), unburnt or partly combusted fuel such as organic carbon (OC), sulphur, ammonium components (for example sulphates from fuel sulphur and nitrates), and lubricant products that is ash and additives (US. EPA, 2005). The particulates and gaseous pollutants, alone and in combination, can cause serious setbacks to the overall physiology of plants (Anda, 1986). Of all plant parts, the leaf is the most sensitive part to the air pollutants and several other such external factors (Lal and Singh, 1990). Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollutant level in the air environment (Shannigrahi *et al.*, 2004). Emissions of particulate matter from combustion sources consist of many different types of compounds, including ammonium components (nitrates and sulphates), carbons, oxides, and any uncombusted elements in the fuel. These can be corrosive and toxic to plants and animals depending on their quantities (R. Andrews,

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1999). Besides adverse health effects, air pollutants can have negative direct or indirect effects on plants also huge economic damage can occur as a result of crop damage (Muller *et al.* 2011). Particulate matters have negative mechanical effects on plants as they cover leaf blades thereby blocking sunlight penetration and also prevent the opening of the stomata and these negatively affect photosynthesis (I. F. Gheorghe and B. Ion, 2011). In the interception of light by a canopy, absorbed solar incident radiation and reflected radiation by the soil surface (Villalobos *et al.*, 2002), is a determining factor in crop development and provides the energy needed for fundamental physiological processes such as photosynthesis and transpiration. Plants intercept direct and diffuse sunlight. The upper leaves receive both types of radiation, while the lower leaves intercept a small portion of direct radiation. Diffuse radiation therefore, becomes more significant in the lower leaves due to radiation transmitted and reflected from the leaves and the soil surface. Particulate matter consists of extremely fine carbon containing particles that are responsible for the blackening of plants and browning of the leaves. These in general block the pores of the leaf surface thereby reducing the gaseous exchange between the plant and the atmosphere. They block sunlight infiltration, can result in leaf injury, damage to the stomata, premature senescence and reduce photosynthetic activity. This has subsequent effects of reduced radiation use efficiency, growth and finally low yields (S. M. Seyyednejad *et al.*, 2011).

MATERIALS AND METHODS

A field experiment was conducted during Rabi season 2013 and 2014 at Industrial area Jagdishpur (Amethi) non-industrial area at Instructional Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) located at 25 km away from experimental site Jagdishpur. Industrial experimental sites namely Jafarganj and Sindurva is located near Jagdishpur industrial area which is situated in Amethi district undivided Sultanpur district on the national highway No. 56 and 83.4 km from Lucknow towards east The details of experiment and treatments have been given elsewhere (Singh R *et. al.*, 2015).

Concentration of suspended particulate matter (SPM) was measured with Respirable dust sampler (RDS) Envirotech make PM 2.5 as shown in plate-1.

Plate 1 : Respirable dust sampler (RDS)

Systematic measurement of SPM through respirable dust sampler (RDS) has been presented through flow chart as given below

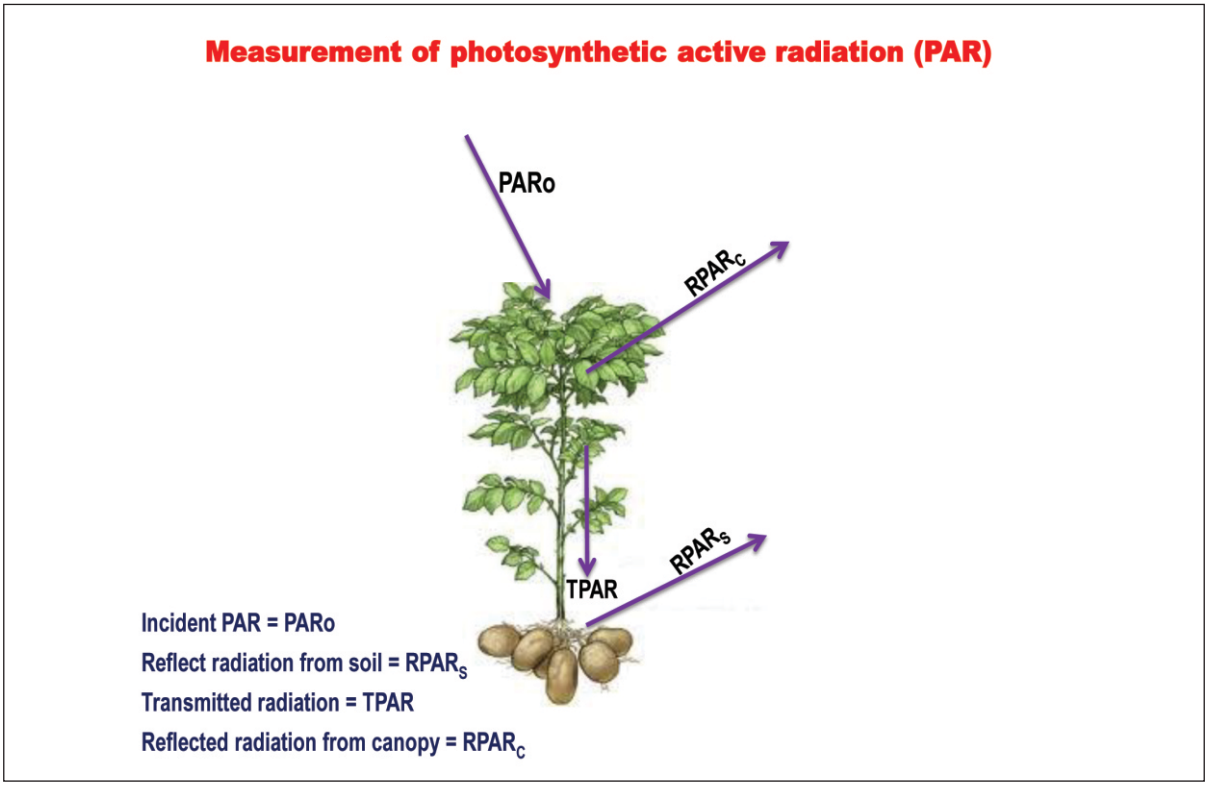
Flow chart of systematic measurement of SPM

Checked the filter for any physical damages
↓
Marked identification number on the filter
↓
Conditioned the filter in conditioning room / desicator for 24 hours
↓
Recorded initial weight
↓
Placed the filter on the sampler
↓
Run the sampler for eight hours
↓
Recorded the flow rate on hourly basis
↓
Removed the filter from the sampler
↓

Kept the exposed filter in a proper container
↓
Recorded the total time of sampling & average flow rate
↓
Again conditioned the filter in conditioning room / desicator for 24 hours
↓
Recorded final weight
↓
Finally calculated the concentration of PM 2.5 in µg/m3

The ambient air quality status during experimental period has been carried out at both study area and quality of ambient air is determined by index value known as the air quality index (AQI). Interception of light was measured days interval periodically at 15 in all replications of each treatment at three places by Yarco make digital lux meter range of 106 Lux capacity. Light interception by the crop canopy in each plot was measured at different DAS in all three dates of sowing in both industrial and non-industrial area. Measurements were taken parallel to the ground surface above the plant canopy to quantify total incoming PAR and below the canopy on the soil surface to quantify PAR passing through the canopy. The ends of the sensor were placed in the middle of adjacent potato rows. The fraction of PAR intercepted was calculated by dividing the soil surface value by the above canopy value (Frederick *et al.* 1998). To ensure continuity in the data, measurements was made on periodical observations at 15 days after sowing were recorded for incident PAR (PARo), transmitted PAR (TPAR), reflected PAR from canopy (RPARC) and reflect PAR from soil (RPARS) with no cloud cover (Tollenaar and Bruulsema 1988). Absorbed PAR (APAR) was then calculated by using the formula

$$APAR\ (\%) = (PARO + RPARS) - (TPAR + RPARC) \quad (1)$$



RESULTS AND DISCUSSION

Average concentration of suspended particulate matter (SPM) in μg/m3 and air quality index at experimental site during 2013-14 during cropping season measured on fortnightly basis at different DAS has been shown in table 1 and the same measurement was done during 2014-15 shown in table 2. From table 1 it was observed that average concentration of SPM measured at two experimental sites namely Jafarganj and Sindurva was minimum (190 μg/m3) on 30th Jan 2014 and maximum 340 μg/m3 at 15th Jan 2014. The concentration at both the sites of industrial area increased from 1st Nov to 15th January then after decreased and recorded minimum on 30th January. Jafarganj site possess higher value of SPM concentration (220 μg/m3) as compared to Sindurva (160 μg/m3) but the highest value at both the sites during 2013-14 was 345 and 335 respectively, though highest and lowest value of SPM recorded at Jafarganj was higher than corresponding value at Sindurva. Total average value of SPM at Jafarganj during cropping period was lower (271.66 μg/m3) as compared to sindurva (278.33 μg/m3). Air quality index as indicated in the table ranged between 38-68 in industrial area. Range of air quality index between 0-25 is supposed to be clean air (least SPM) and ranged between 51-75 as moderate air (more concentration of SPM) the rating scale of air quality index has been shown in table 3. The lowest value of air quality index 38 was recorded on 30th January 2014 and maximum value 68 on 15th January 2014. This means on 30th January concentration of SPM in the atmosphere was least (clean air) hence may be maximum absorption of solar radiation by the crop which may ultimately resulted better in chlorophyll formation. In non-industrial area the quality index was ranged between 15-28, i.e. there was least SPM or clean air during cropping period. As far as concentration of SPM in non-industrial area is concerned it ranged between 30-56 with average value of 44.77 μg/m3 as compared to 275.00 μg/m3 in industrial area which is about six times more as compared to non-industrial area. Similarly from table 2 the SPM concentration measured during second year of experiment 2014-15 in industrial and non-industrial area it was revealed that average concentration of SPM during cropping period was 271.66 μg/m3 as compared to 275.00 μg/m3 during 2013-14.The maximum value of SPM (340 μg/m3) was recorded on 15th January during 2013-14 followed by 30th December 2013. But during 2014-15 the maximum value (335 μg/m3) was recorded on 15th Dec 2014 as compared to 15th Jan 2014, hence from these tables it is experienced that higher concentration of SPM was between 15th Dec to 15th Jan in both the years. Air quality index also support same findings as it ranged between 60-67 during this period. In non-industrial area during 2014-15 maximum SPM concentration ranged between 35-50 μg/m3 with average value of 45.44 μg/m3 and quality index ranged from 17.5-25 with average value of 22.72 hence falls in the clean air zone. The average SPM concentration at industrial site during this year (27.66 μg/m3) also observed about 6 times as compared to non-industrial site this year too (45.44 μg/m3). The index value of air quality from rating scale indicators as mentioned in Table-3 indicated that higher the air quality index (AQI) value, greater the level of air pollution and greater the health concerns (Mohan and Kandya, 2007).

Optical Characteristics of solar radiation of potato crop during 2013-14 & 2014-15 has been depicted in table 4, 5, and table 6 sown at three different dates of sowing D1, D2 & D3. From Table 4 it was concluded that incident radiation falling on above the canopy was maximum 3.80 μmole sec-1m-2 in non-industrial and 3.40 μmole sec-1m-2 in industrial at 105 DAS at first date of sowing. Similarly radiation reflected from above the canopy was maximum 0.36 μmole sec-1m-2 and 0.29μmole sec-1m-2 at 105 DAS in industrial area and non-industrial area respectively. Transmitted radiation has no increasing or decreasing trend in both industrial and non-industrial site. Maximum value of transmitted radiation (3.00 μmole sec-1m-2) at mid canopy was recorded at 75 DAS followed by 2.93 μmole sec-1m-2 at 90 DAS in non-industrial site where as in industrial site maximum value 2.75 μmole sec-1m-2 was recorded at both 75 & 105 DAS. Similarly reflected radiations from soil surface also don't possess any trend but maximum value (0.36 μmole sec-1m-2) and (0.24 μmole sec-1m-2) was recorded at 105 DAS in both the sites. As per the formula for absorbed radiation (eq.1) calculated value of absorbed radiation clearly indicated that maximum absorption of solar radiation from the crop canopy was maximum at 45 DAS of sowing in industrial and non-industrial sites. Maximum value of absorbed radiation in industrial site was 0.49 μmole sec-1m-2 and in non-industrial it was 0.75 μmole sec-1m-2. Maximum absorption of radiation will ultimately result the maximum absorption of photosynthetic

Table 1: Average concentration of suspended particulate matter (SPM) in μg/m3 and quality index at experimental site during 2013-14 in winter season on fortnightly basis.

Year	Date	Industrial Area				Non Industrial Area	
		Jafarganj	Sidurva	Average	Quality Index	SPM	Quality Index
2013-14	1.11.13	220	280	250	50	56	28
	15.11.13	250	270	260	52	40	20
	30.11.13	255	275	265	53	52	26
	15.12.13	300	320	310	62	45	22.5
	30.12.13	315	325	320	64	50	25
	15.01.14	345	335	340	68	50	25
	30.01.14	220	160	190	38	30	15
	15.02.14	250	230	240	48	40	20
	28.02.14	290	310	300	60	40	20
Average		**271.66**	**278.33**	**275.00**	**55**	**44.77**	**23.38**

Table 2: Average concentration of suspended particulate matter (SPM) in $\mu g/m^3$ and quality index at experimental site during 2014-15 in winter season on fortnightly basis.

Year	Date	Industrial Area				Non Industrial Area	
		Jafarganj	Sidurva	Average	Quality Index	SPM	Quality Index
2014-15	1.11.14	250	290	270	54	50	25
	15.11.14	250	280	265	53	48	24
	30.11.14	268	240	254	51	49	24.5
	15.12.14	340	330	335	67	45	22.5
	30.12.14	321	321	321	64	48	24
	15.01.15	350	270	310	62	47	23.5
	30.01.15	200	180	190	38	35	17.5
	15.02.15	230	200	215	43	43	21.50
	28.02.15	315	255	285	57	44	22
Average		280.44	262.88	271.66	54.33	45.44	22.72

Table 3: Rating scale of Air Quality index (AQI).

Rating Scale	Index Value
Clean air (CA)	0 – 25
Light polluted air (LPA)	26 – 50
Moderately air polluted (MAP)	51 – 75
Heavy air polluted (HAP)	76 -100
Severe air polluted (SAP)	> 101

Table 4: Optical Characteristics of solar radiation (μmole $sec^{-1}m^{-2}$) of potato crop at first date of sowing (D_1) (average of 2013-14 and 2014-15).

Year	DAS	Incident Radiation above the canopy		Reflected radiation from upper canopy		Transmitted radiation at mid canopy		Reflected radiation from soil surface		Absorbed Radiation	
		1		2		3		4			
		I	NI	I	NI	I	NI	I	NI	I	NI
1	30	2.90	3.50	0.21	0.20	2.35	3.01	0.12	0.11	0.22	0.18
2	45	2.60	3.80	0.19	0.29	1.75	2.55	0.17	0.21	0.49	0.75
3	60	2.90	3.20	0.12	0.30	2.47	2.50	0.10	0.12	0.21	0.28
4	75	3.40	3.60	0.16	0.35	2.75	3.00	0.12	0.14	0.37	0.10
5	90	2.90	3.50	0.18	0.26	2.50	2.93	0.16	0.20	0.06	0.11
6	105	3.40	3.80	0.29	0.36	2.75	2.90	0.24	0.36	0.12	0.19

NOTE
1 & 2 = One feet above the top of canopy
4 = Soil surface above 2-3cm
I = Industrial Area (Jagdishpur sites)
NI = Non Industrial Area (N.D.U.A.T. Instructional Farm)

radiation hence in chlorophyll formation. Reflected radiation from above the canopy was least during this period ranged between 0.12 to 0.29 μmole sec-1m-2 in industrial site may be due to more deposition of atmospheric pollutants (SPM) during 60-105 DAS.

From Table 5 it was concluded that incident radiation falling on above the canopy was maximum 3.60 μmole sec-1m-2 in non-industrial at 75 DAS and 3.30 μmole sec-1m-2 in industrial at 30 DAS at second date of sowing (1st November). Similarly radiation reflected from above the canopy was maximum 0.40 μmole sec-1m-2 in non-industrial area and 0.32 μmole sec-1m-2 in industrial area at 30 DAS. Transmitted radiation has no trend of increasing or decreasing in industrial and non-industrial site. Maximum value of transmitted radiation 2.80 μmole sec-1m-2 recorded at 90 DAS in non- industrial area followed by 2.71 μmole sec-1m-2 at 30 DAS where as in industrial site maximum value 2.90 μmole sec-1m-2 was recorded at 90 DAS. Similarly reflected radiations from soil surface also don't possess any trend but in non-industrial area maximum value 0.24 μmole sec-1m-2 was recorded at 60 DAS and 0.19 μmole sec-1m-2 at 105DAS in industrial and industrial sites. The absorbed radiation calculated as per (eq.1) indicated that maximum

Table 5: Optical Characteristics of solar radiation (μmole $sec^{-1}m$-2) of potato crop at second date of sowing (D2) (average of 2013-14 and 2014-15)

Year	DAS	Incident Radiation above the canopy		Reflected radiation from upper canopy		Transmitted radiation at mid canopy		Reflected radiation from soil surface		Absorbed Radiation	
		1		2		3		4			
		I	NI	I	NI	I	NI	I	NI	I	NI
1	30	3.30	3.50	0.32	0.40	2.71	2.60	0.12	0.18	0.15	0.32
2	45	3.00	2.90	0.20	0.29	2.60	2.50	0.10	0.12	0.10	0.01
3	60	2.60	2.80	0.27	0.39	1.85	2.90	0.17	0.24	0.31	0.73
4	75	3.10	3.60	0.26	0.36	2.50	2.90	0.15	0.14	0.19	0.20
5	90	3.20	3.40	0.24	0.38	2.80	2.60	0.12	0.20	0.04	0.22
6	105	2.40	3.40	0.28	0.30	1.90	2.75	0.19	0.19	0.03	0.16

NOTE
1 & 2 = One feet above the top of canopy
4 = Soil surface above 2-3cm
I = Industrial Area (Jagdishpur sites)
NI = Non Industrial Area (N.D.U.A.T. Instructional Farm)

Table 6: Optical Characteristics of solar radiation (μmole $sec^{-1}m^{-2}$) of potato crop at third date of sowing (D3) (average of 2013-14 and 2014-15).

Year	DAS	Incident Radiation above the canopy		Reflected radiation from upper canopy		Transmitted radiation at mid canopy		Reflected radiation from soil surface		Absorbed Radiation	
		1		2		3		4			
		I	NI	I	NI	I	NI	I	NI	I	NI
1	30	3.20	3.20	0.22	0.35	2.55	2.40	0.10	0.21	0.33	0.24
2	45	3.60	3.85	0.26	0.33	2.81	2.90	0.14	0.19	0.39	0.43
3	60	3.20	3.60	0.18	0.26	2.71	2.94	0.18	0.14	0.13	0.26
4	75	3.30	3.80	0.39	0.29	2.60	2.50	0.16	0.12	0.60	0.89
5	90	2.60	3.50	0.29	0.39	1.90	2.60	0.21	0.23	0.20	0.28
6	105	2.80	3.75	0.25	0.45	1.80	2.80	0.19	0.18	0.56	0.32

NOTE
1 & 2 = One feet above the top of canopy
4 = Soil surface above 2-3cm
I = Industrial Area (Jagdishpur sites)
NI = Non Industrial Area (N.D.U.A.T. Instructional Farm)

absorption of solar radiation from the crop canopy was highest 0.73 μmole sec-1m-2 at 60 DAS in non-industrial and 0.31 μmole sec-1m-2 in industrial site. Maximum absorption of radiation will ultimately result the maximum absorption of photosynthetic radiation hence chlorophyll formation. Reflected radiation from above the canopy was least during this period ranged between 0.20 to 0.32 μmole sec-1m-2 in industrial site may be due to more deposition of atmospheric pollutants (SPM) during 30-45 DAS. Absorption of solar radiation by potato crop effected by pollutants as minimum absorption of suspended particulates results higher absorpion of solar radiations which may ultimately affects the yield of crop through physiological characters of potato crop.

From Table 6 it was revealed that the incident radiation falling on above the canopy was maximum 3.85 μmole sec-1m-2 in non-industrial and 3.60 in industrial at 45 DAS at third date of sowing (15th November). Similarly radiation reflected from above the canopy was maximum 0.39 μmole sec-1m-2 at 75DAS in industrial area and 0.45 μmole sec-1m-2 in non-industrial area at 105 DAS. Transmitted radiation has no trend of increasing or decreasing in industrial and non-industrial site. Maximum value of transmitted radiation 2.94 μmole sec-1m-2 recorded at 60 DAS followed by 2.90 μmole sec-1m-2 at 45 DAS in non-industrial site where as in industrial site maximum value 2.81 μmole sec-1m-2 was recorded at 45 DAS followed by 2.71 μmole sec-1m-2 at 60 DAS. Similarly reflected radiations from soil surface also don't possess any trend but in non-industrial area maximum value 0.23 μmole sec-1m-2 was recorded and 0.21 μmole sec-1m-2 in industrial sites value was recorded at 90 DAS. The value of absorbed radiation indicated that maximum absorption of solar radiation from the crop canopy was maximum 0.89 in industrial and 0.60 in non-industrial sites at 75 DAS. Reflected radiation from above the canopy was least during this period ranged between 0.18 μmole sec-1m-2 to 0.39 μmole sec-1m-2 in industrial site may be due to more deposition of atmospheric pollutants (SPM) during 60-75 DAS.

CONCLUSIONS

The result of study showed that SPM have detrimental effects on potato crops. Changes in morphological characteristics, photosynthetic pigment of potato crop directly corresponded to the levels of air pollutants at different sites sown under variable weather conditions. Absorption of solar radiation by potato crop also effected by pollutants as minimum absorption of suspended particulates results higher absorpion of solar radiations which mayultimately affects the yield of potato crop through physiological characters of potato crop. It was also concluded that urban and industrial SPM has become a serious threat to agricultural production especially potato crop grown adjacent to urban and industrial areas.

Table 7: List of abbreviations

S. No.	Abbreviations	Full form
1.	SPM	Suspended Particulate Matters
2.	AQI	Average Air Quality Index
3.	EC	elemental carbon
4.	OC	Organic Carbon
5.	RDS	Respirable dust sampler
6.	PAR	Photosynthetic active radiation
7.	TPAR	Transmitted Photosynthetic active radiation
8.	RPARC	Reflected photosynthetic active radiation from canopy
9.	RPARS	Reflected photosynthetic active radiation from soil with no cloud cover
10.	APAR	Absorbed photosynthetic active radiation
11.	DAS	Days after sowing

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PM_{10} Sources and its Level in the Ambient Air of a Hilly Ecosystem

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ABSTRACT

This study deals with the ground based measurement of particulate matter and Satellite data validation over Shimla in north western Indian Himalaya along with factors like precipitation, vehicular population and tourist influx. PM_{10} samples were collected during the study period from April 10 to March 11. The observed higher values of PM_{10} during comparatively smoky, dust loaded and hazy days was analyzed with simultaneous study of the Back Trajectory (Hysplit Model) Plotted, precipitation data, Vehicular population trend and Tourist Influx to the study area. The study suggests the correlation among the factors affecting the concentration of PM_{10} observed. The study concludes that there is an influx of desert aerosol to the study area from far off places as a global source and considerable and consistent increase in the tourist inflow and vehicular population in the study area impacting PM_{10} locally. The rainfall plays a handy role in the present scenario of rising pollution level as it lowers the concentration in the ambient air through wet deposition.

Key words: Particulate Matter, Tourist Influx, Vehicular Population, Back Trajectory, Rainfall.

INTRODUCTION

The entire globe is currently facing two fold crisis of fossil fuel depletion and Environmental Degradation. The global air pollution is a serious problem. The air is highly polluted in terms of suspended particle matter in most cities (Prasad *et al.* 2003). Much of this pollution is caused by the use of fossil fuels for transportation. The quantity of aerosol has been increasing as a function of human and anthropogenic activities; consequently imparting an increasing impact upon climate change (IPCC, 2001; IPCC, 2007).

Suspended Particulate Matter in ambient air is a complex, multiphase system consisting of a spectrum of aerodynamic particle sizes ranging from below 0.01 μm to 100 μm and larger. The Respirable particles are attributed to the growth of particles from the gas particles and subsequent agglomeration. The newly formed aerosols become climatically important only if they are able to grow to sizes of 50 nm and larger. Particles in this size range can act as cloud condensation nuclei (Twomey 1974; Pirjola *et al.*, 2002; Laaksonen *et al.*, 2005; Kaufman *et al.*, 2006) and they contribute to indirect aerosol effect on the climate (Lehtinen and Kulmala, 2003). Their impact on human health is also a subject of increasing concern (Pope *et al.* 2002; Kuenzli *et al.* 2000; Samet *et al.* 2000). EPA in 1987, replaced the primary standard for TSP

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with PM_{10} standard which included only particles with an aerodynamic diameter of 10 μm or less in view of the ability of these particles to penetrate deep into the lung that have direct health effects.

The principal aim of the present study is to quantify the sources of particulate pollution especially PM_{10}. This study is based on the PM_{10} sampling conducted at the Ridge in Shimla, Himachal Pradesh, India. The monitoring has been done as per the guidelines of Central Pollution Control Board, Ministry of Environment & Forests, Government of India. The sampling was carried out on alternate days for 24 hours. The PM_{10} mass concentration for considerably high pollution days is presented for the year 2010-11. HYSPLIT-Back Trajectories Model was also plotted to investigate transport of particulate matter. Data on the Rainfall was also collected from Hydromet Division of Indian Meteorological Department. Being a popular Hill Station among tourists, data on the tourist arrival and vehicular population was also collected to observe the trend.

Site Description and Synoptic Meteorology: Shimla is a famous tourist hill station visited by Lacs of tourists every month. The experimental site is at the Centre of the Shimla City located at the Ridge, Shimla in the northwestern part of Indian Himalaya at 31°6'11"N latitude and 77°10'19"E. The Himalaya, including northwestern part is considered very fragile and ecologically very sensitive. The experimental site is located on the top of a ridge, near Jakhu Hill, at an elevation of 2210 meter above mean sea level which is open from three sides. The surrounding environment in the immediate vicinity of the experimental site is dominated by tourism and agro-horticulture activities. Tourism industry has been a significant factor in the State GDP of Himachal Pradesh and Shimla has experienced a tremendous tourism growth over the last decade. The population of Shimla town is about 1.68 Lacs (Provisional census data, 2011). Rapid urbanization has been observed in the recent past.

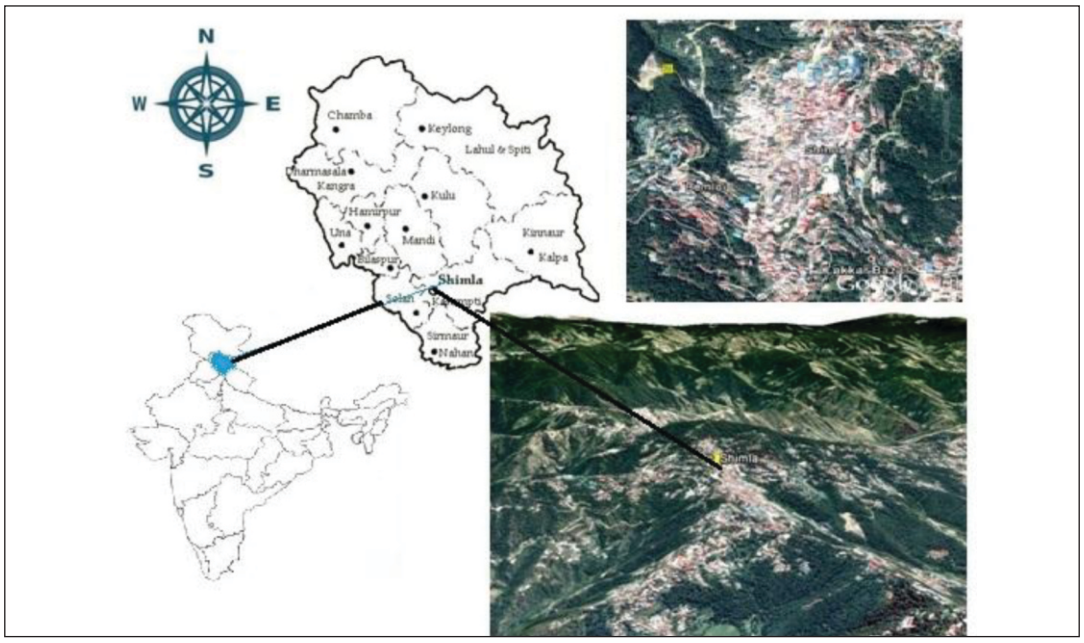


Fig. 1: Google Map View of the Sampling site and surroundings

The climate of Shimla can be classified into four local seasons; winter (December - March), is associated with rain and snowfall. The winter season contributes about 15-20% of the precipitation. The main precipitation bearing season is during monsoon i.e. June-September which contributes about 60-75% of the annual precipitation. The autumn season (October-November) experiences moderate to low temperature with rare rainfall. The summer season is relatively short i.e. April-May. The maximum temperature generally reaches up to 32°C. The annual average temperature, wind speed, RH and rainfall during 2010-11 were 16 °C, 0.28 ms^{-1}, 52.79% and107mm respectively.

MATERIALS AND METHODS

Respirable Dust Sampler: Envirotech Model APM 460NL was used for ambient air sampling wherein air is drawn through a size selective inlet at a flow rate 0.9-1.4 m^3/min free flow. The sampler uses cyclone to separate the coarser particles (>10 microns) from the air stream before filtering it on the 0.5 micron pore-size quartz filter paper (8"x10" size) allowing a measurement of both TSP and Respirable fraction of Suspended Particulate Matter. Thus, Particles of 10 microns & below are collected on the filter paper. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM_{10} is calculated by dividing the weight gain of the filter by the volume of air sampled. The air quality is generally categorized into four broad categories based on an Exceedence Factor. The Exceedence Factor (EF) is calculated as:

Exceeding Factor=Observed annual mean conc. of criteria pollutant / Annual standard for the respective pollutant and area class

The four air quality categories are:

- Critical Pollution (C) : when EF is > 1.5;
- High Pollution (H) : when the EF is between 1.0 - <1.5;
- Moderate Pollution (M) : when the EF between 0.5 - <1.0; and
- Low Pollution (L): when the EF is < 0.5.

As per study during 2010-11, Shimla falls in Moderate Pollution category w.r.t. PM_{10} with EF 0.91, however, likely to exceed the standards in future if pollution continues to increase and is not controlled.

Rain Fall: Rainfall impacts the pollutant level in the ambient air as precipitation results in wet deposition of particulate matter, aerosols and gaseous air pollutants. Precipitation data recorded by the meteorological department during the period has also been analyzed to understand the possible correlation and impact on the concentration of PM_{10} measured at ground level. During the year 2010-11, total rainfall of 1286 mm was recorded in Shimla. Month wise data of rainfall recorded is given below;

Table 1: Month Wise Data of the Rainfall Recorded in Shimla

April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
20.7	49.8	155.0	303.5	280.4	261.6	26.5	8.3	52.8	31.1	60.7	35.6

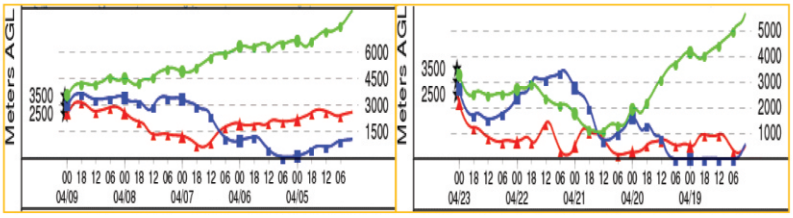
Vehicular Population: As per study, (Kumar and Goyal, 2014) percentage of PM_{10} pollutant contributed by diesel, petrol and CNG (81%, 13%, 6%) respectively. The percentage of PM_{10} from diesel vehicles is found to be more in comparison to petrol and CNG, which is accepted as sulfur has been contained in diesel fuel and favorable to increase the particulate emission. Vehicular population registered in Shimla urban as on 31.03.2011 was 55746 which has shown considerable rise.

Tourist Influx Data: Tourism in Himachal Pradesh is one of the most important sectors for the state's economy. Large number of tourist's inflow leads to very high vehicular influx as well and as the state being hilly, the rail and air connections are limited. Final estimate of the domestic and foreign tourist arrival in Shimla for the period 2010-11 was 26,75,052 which has shown consistent rise over the years.

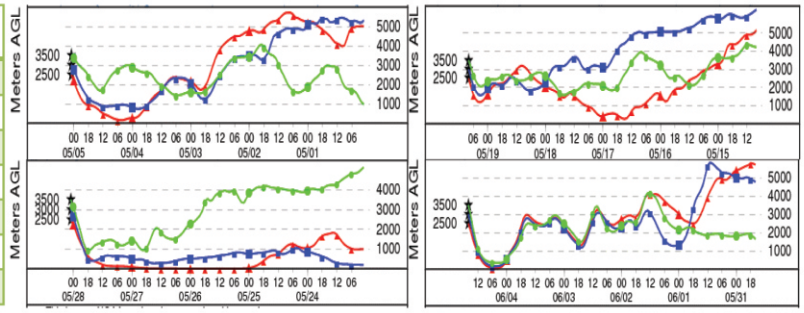
Satellite Measurements: To examine external sources that contribute to the existing columnar aerosols, 5 day backward trajectories using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Model was plotted in terms of their transport (Draxler and Ralph, 2010). The trajectories were calculated at three arrival heights 2500, 3000 and 3500m above ground level. The lowest level was selected as 2500m keeping in mind the topography and height of Jakhu hill located on one side of the experimental site at the Ridge. Satellite retrievals add synoptic and geospatial context to ground based air quality measurements. Such context is applied for qualitative and quantitative analysis of events that affect air quality. To investigate the influence of aerosol transport over Shimla, satellite measurement hysplit model using back trajectories terminating at 2500m, 3000m and 3500m were plotted for analysis.

Table 2: Comparative Data of Smoky, Dust Loaded and Hazy Days with Simultaneous Study of the Back Trajectory (Hysplit Model) Terminating Over Study Area.

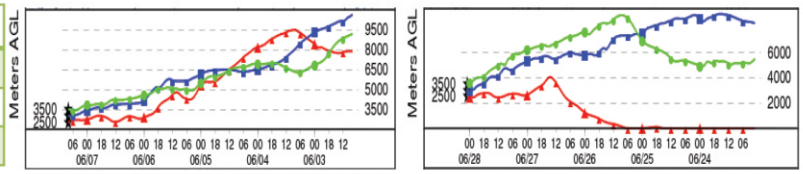
Date	6AM -2PM	2PM-10PM	10PM-6AM
05.04.2010	98	115	38
07.04.2010	**170**	39	83
21.04.2010	75	78	**122**
23.04.2010	117	63	119



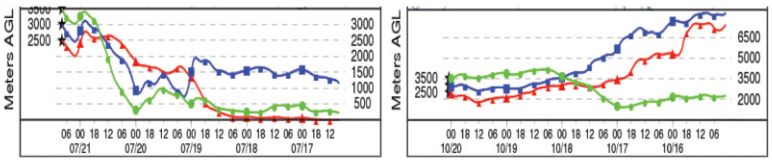
Date	6AM-2PM	2PM-10PM	10PM-6AM
05.05.2010	85	71	111
12.05.2010	41	40	36
17.05.2010	90	83	116
19.05.2010	115	33	**128**
26.05.2010	44	101	59
28.05.2010	104	**155**	**191**
31.05.2010	**137**	61	48



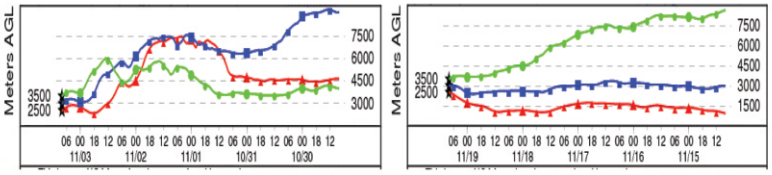
Date	6AM-2PM	2PM-10PM	10PM-6AM
04.06.2010	**164**	**167**	92
07.06.2010	**138**	–**	–**
28.06.2010	47	49	**168**



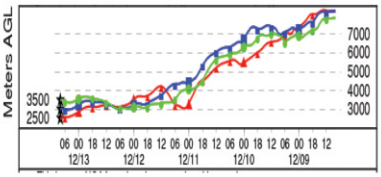
Date	6AM-2PM	2PM-10PM	10PM-6AM
21.07.2010	111	44	28
Date	**6AM-2PM**	**2PM-10PM**	**10PM-6AM**
20.10.2010	**138**	80	_**



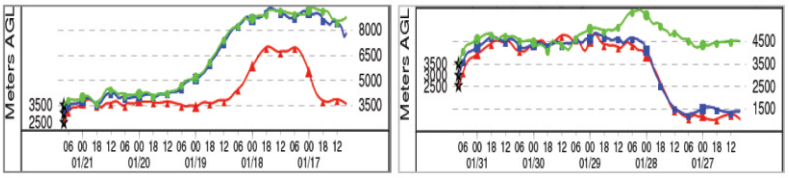
Date	6AM-2PM	2PM-10PM	10PM-6AM
03.11.2010	**111**	66	37
15.11.2010	35	54	_*
19.11.2010	111	87	13



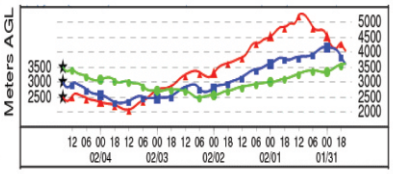
Date	6AM-2PM	2PM-10PM	10PM-6AM
10.12.2010	19	109	34
13.12.2010	116	40	_*



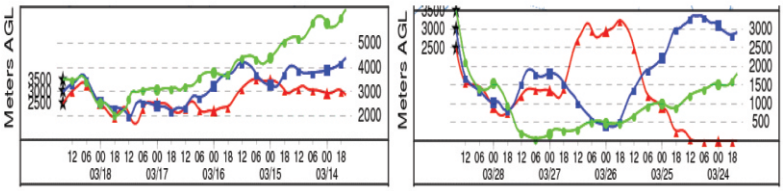
Date	6AM-2PM	2PM-10PM	10PM-6AM
21.01.2011	116	80	6
28.01.2011	74	**128**	42
31.01.2011	103	13	22



Date	6AM-2PM	2PM-10PM	10PM-6AM
02.02.2011	46	100	50
04.02.2011	43	**157**	28
07.02.2011	87	_*	_*



Date	6AM-2PM	2PM-10PM	10PM-6AM
18.03.2011	33	**127**	56
21.03.2011	41	**199**	28
25.03.2011	**131**	116	76
28.03.2011	64	**142**	27



RESULTS AND DISCUSSION

The major man made sources of pollution in the area are emission from diesel vehicles like bus/trucks, resuspension of road dust and burning of Biomass, agro-horticulture activities, forest fires etc. Road dust has been acknowledged as an important source of urban air pollution as resuspended particles from paved roads can considerably enhance atmospheric particulate matter (PM) levels (Thorpe and Harrison 2008; Amato et al., 2009a; Karanasiou et al., 2009, 2011). Vehicular population registered in Shimla as on 31.03.2010 was about 44876 which shoot up to 55746 as on 31.03.2011. Fig. 2 shows percentage

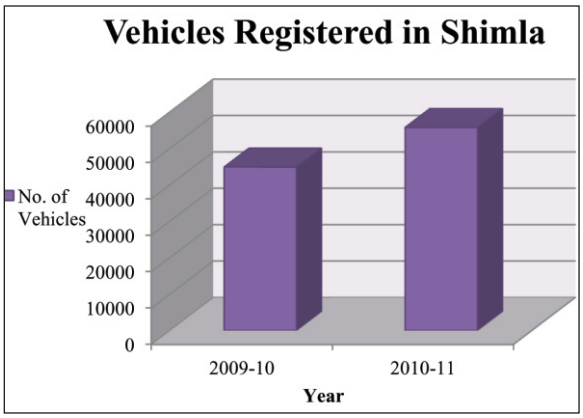


Fig. 2 : Year wise Increase in Vehicular Population in Shimla Urban

rise in the number of registered vehicle in a year observed to be 24.22%. Growth in population, number of tourists visiting the city and around, change in land use, commercial activities and vehicular populations has resulted in increase in pollution level cumulatively (Kumar and Singh, 2011). Traffic in urban areas significantly contributes to the ambient air pollution level, which has been linked to adverse health effects among children and adults (Sergy et al, 2014). Many epidemiological studies have documented significant positive correlation between daily mean concentrations of air pollution, Respirable Particulate Matter ($PM_{2.5}$, PM_{10}) and increased mortality and morbidity attribute to respiratory and cardiovascular causes (USEPA, 1996; Schwartz et al., 2002; Pope et al., 2002). It is

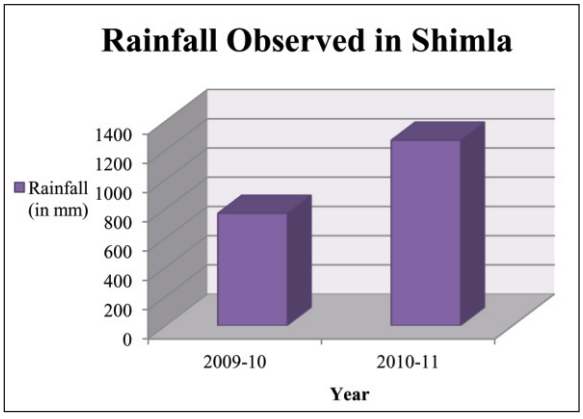


Fig. 3 : Comparative Data of Rainfall in Shimla

estimated that the incidence of mortality and morbidity in different groups in India is due to exposure to PM_{10}. These impacts translate into economic values. The result indicated 2.5 million premature deaths and total morbidity and mortality costs range from Rs.885 billion to Rs.4250 billion annually region wide. Urban air pollution is estimated to cause 250000 deaths and billions of cases of respiratory illness every year (World Bank, 2005). Considerable increase in the number of registered vehicles is also responsible for particulate emissions. Several studies have shown that traffic related particles seemed to be more toxic than others. Multicity studies have shown that association between PM_{10} concentrations and increased risk of death generally remains unchanged after control of other pollutants (Dominici et al., 2005; Dominici et al., 2007). We observed significant seasonal variability in particulate pollutants with higher concentrations in late winter months, summer months and lowest during monsoon/rainy season which is directly proportional to the rainfall pattern generally observed. Fig. 3 provides the comparative data on rainfall recorded during 2009-10 and 2010-11 and interestingly during 2010-11 PM_{10} level was lower than the preceding year. Every year significant rise in tourist inflow to Shimla has been observed. Fig. 4 gives yearly percentage rise in number which has been observed as 17.17% Majority of the tourists visit with hired vehicles or their own vehicles from outside the State, so the actual number of vehicles plying in the area of study is much more. Impact of the vehicular emission to the ambient air concentration in the study area cannot be ignored. We observed significant seasonal variability in particulate pollutants with higher concentrations in late winter months, summer months and lowest during monsoon/rainy season which is directly proportional to the rainfall pattern generally observed. Fig. 3 provides the comparative data on rainfall recorded during 2009-10 and 2010-11 and interestingly during 2010-11 PM_{10} level was

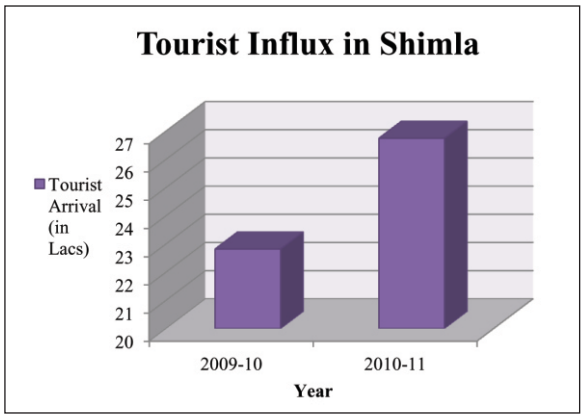
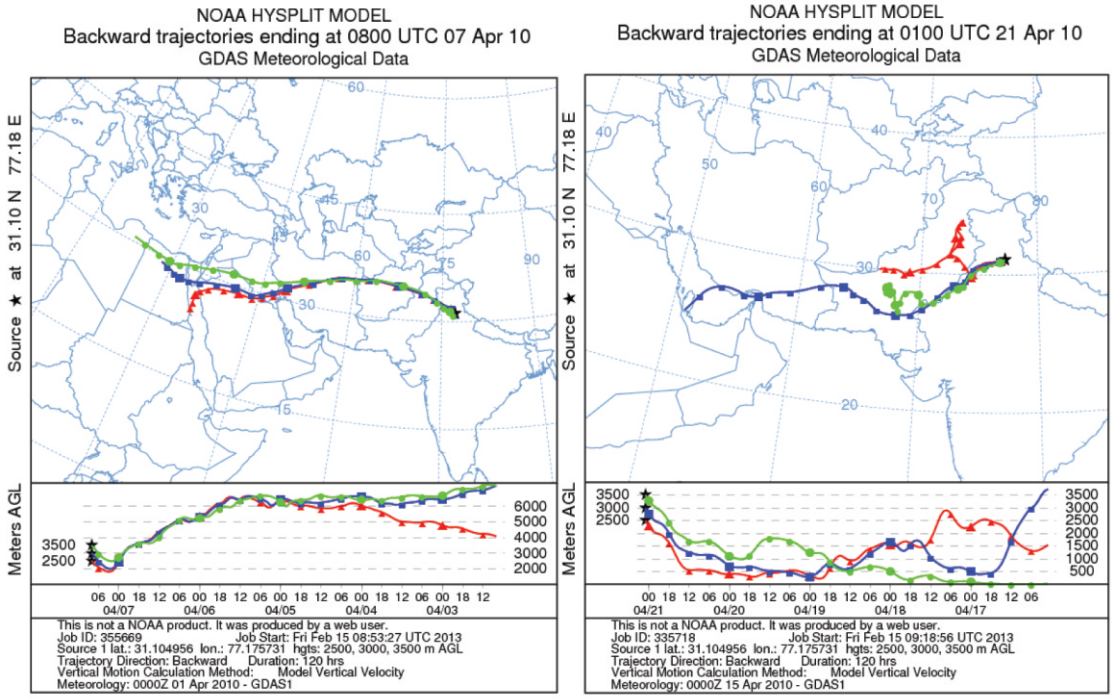
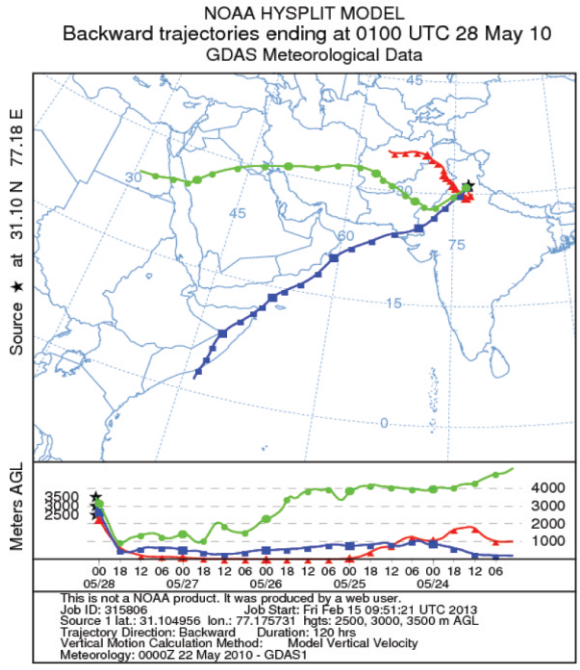
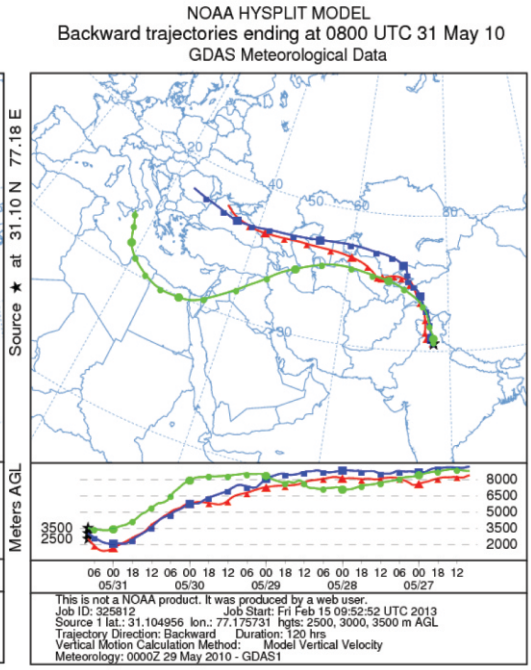


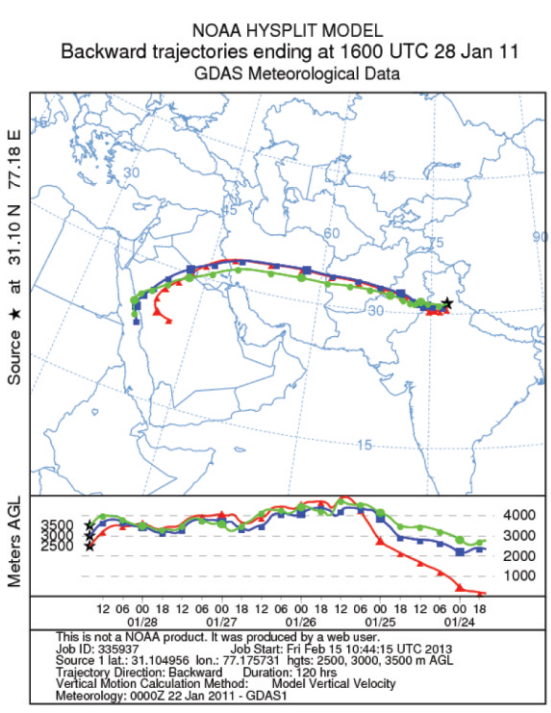
Fig. 4 : Graph Showing Increase in tourist Inflow to Shimla

lower than the preceding year. The observed higher values of PM_{10} during smoky, dust loaded and hazy days with simultaneous study of the Back Trajectory (Hysplit Model) analysis (Fig. 5) suggest influx of desert aerosol. It shows long range transport of particulate matter for far off places at different altitude. The measures like check on vehicular population & their emissions, adulteration of fuel & fuel products and improvement in condition of roads are required.




NOAA HYSPLIT MODEL
Backward trajectories ending at 0100 UTC 28 May 10
GDAS Meteorological Data
Source ★ at 31.10 N 77.18 E
Meters AGL
This is not a NOAA product. It was produced by a web user.
Job ID: 315806 Job Start: Fri Feb 15 09:51:21 UTC 2013
Source 1 lat.: 31.104956 lon.: 77.175731 hgts: 2500, 3000, 3500 m AGL
Trajectory Direction: Backward Duration: 120 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 22 May 2010 - GDAS1


NOAA HYSPLIT MODEL
Backward trajectories ending at 0800 UTC 31 May 10
GDAS Meteorological Data
Source ★ at 31.10 N 77.18 E
Meters AGL
This is not a NOAA product. It was produced by a web user.
Job ID: 325812 Job Start: Fri Feb 15 09:52:52 UTC 2013
Source 1 lat.: 31.104956 lon.: 77.175731 hgts: 2500, 3000, 3500 m AGL
Trajectory Direction: Backward Duration: 120 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 29 May 2010 - GDAS1


NOAA HYSPLIT MODEL
Backward trajectories ending at 1600 UTC 28 Jan 11
GDAS Meteorological Data
Source ★ at 31.10 N 77.18 E
Meters AGL
This is not a NOAA product. It was produced by a web user.
Job ID: 335937 Job Start: Fri Feb 15 10:44:15 UTC 2013
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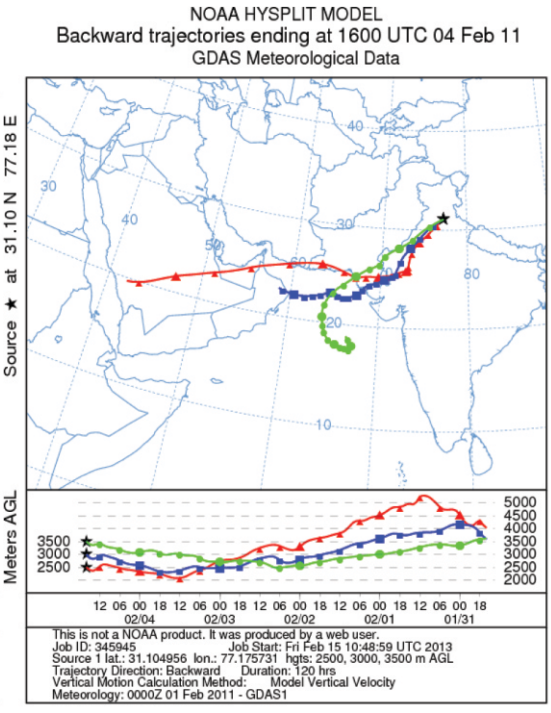
Trajectory Direction: Backward Duration: 120 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 22 Jan 2011 - GDAS1


NOAA HYSPLIT MODEL
Backward trajectories ending at 1600 UTC 04 Feb 11
GDAS Meteorological Data
Source ★ at 31.10 N 77.18 E
Meters AGL
This is not a NOAA product. It was produced by a web user.
Job ID: 345945 Job Start: Fri Feb 15 10:48:59 UTC 2013
Source 1 lat.: 31.104956 lon.: 77.175731 hgts: 2500, 3000, 3500 m AGL
Trajectory Direction: Backward Duration: 120 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 01 Feb 2011 - GDAS1

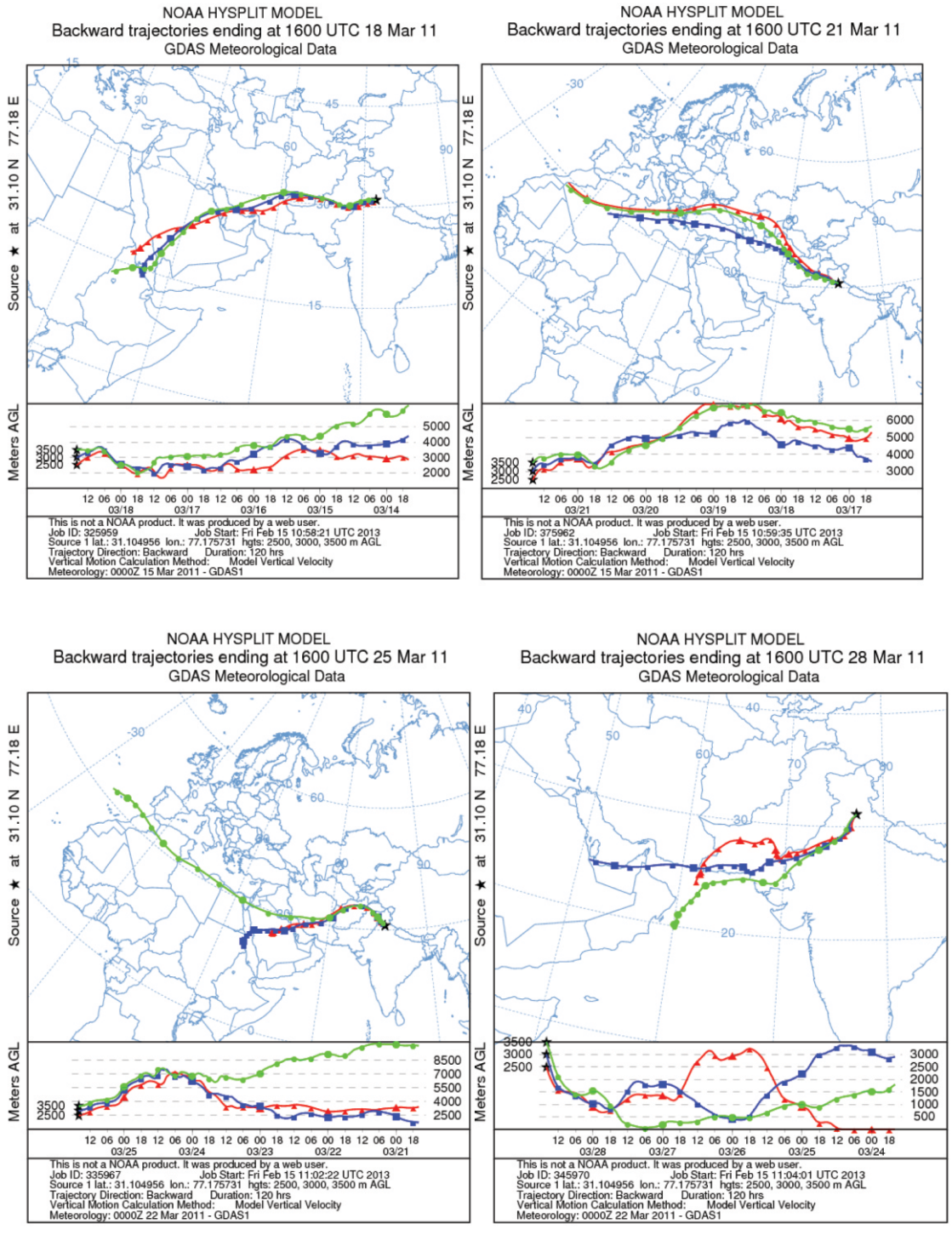


Fig. 5 : Five-day backward trajectories obtained for high pollution days (http://ready.arl.noaa.gov/ HYSPLIT. php, NOAA Air Resources Laboratory, United States).

CONCLUSIONS

It is observed that the concentration of PM_{10} level at the experimental site is not far from the annual standard of 60μg/m^3 prescribed for the area as per National Ambient Air Quality Standards (NAAQS) by Ministry of Environment Forests/ Central Pollution Control Board, Delhi with Exceeding Factor of 0.91. However, it is likely to exceed the standards in future if pollution continues to increase and no mitigation / controlling measures taken. Considerable and steady rise in both tourist inflow and number of registered vehicles are the significant contributors of PM_{10}. It can be concluded from the above discussed observations that precipitation does affect the pollution level locally through wet deposition. HYSPLIT-Back Trajectories analysis also suggests influx of desert aerosol to the study area. It shows long range transport of particulate matter from far off places at different altitude whose contribution to the pollution level cannot be ignored.

ACKNOWLEDGEMENTS

We thank the H.P. State Pollution Control Board, Shimla and Central Pollution Control Board, Ministry of Environment & Forests, Govt. of India, New Delhi for providing facilities under NAMP programme. We acknowledge NOAA Air Resources Laboratory for provision of the HYSPLIT Model for back trajectories which has been used in this publication. We are also grateful to Department of Transport, Department of Tourism and Civil Aviation and IMD for providing data. We also heartily thank the reviewers for constructive comments and suggestions.

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International Journal on Environmental Sciences **6** (2) : 217-225, July-December 2015 **Research Article**
(ISSN No.: 0976-4534)

Physico-chemical and Statistical Assessment of Water Quality of River Yamuna in Mathura-Agra Region

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ABSTRACT

The Yamuna River plays a fundamental yet essential role in modern society by acting as a source of irrigation, drinking water and as a sink for urban wastewater. The present study deals with the analysis of the physicochemical parameters of surface water of River Yamuna at six different locations in Mathura-Agra, Uttar Pradesh. The parameters examined were pH, temperature, electrical conductivity, TDS, TSS, alkalinity, total hardness, chloride, phosphate, sulphate, nitrate, COD, BOD and DO at selected sampling sites. The results showed that water quality at these sites were not in permissible limits. Systematic calculations of correlation coefficient and ANOVA between water quality parameters have also been done with the objective of minimizing the complexity and dimensionality of a large set of data. A significant positive correlation was observed between temperature - pH, total hardness - total alkalinity, dissolved oxygen - total suspended solids, chemical oxygen demand - electrical conductivity and electrical conductivity – total alkalinity. The skewness value was negative for temperature, BOD, pH and nitrate but also positive for total hardness, DO, COD, t-A, TDS, TSS, chloride, phosphate, sulphate and electrical conductivity. Curve was platykurtic for BOD, sulphate, chloride and TDS where as leptokurtic curve was shown by temperature, total hardness, pH, DO, COD, TSS, phosphate, electrical conductivity, nitrate and total alkalinity. High standard deviation values of total hardness, TSS, COD, TDS and conductivity suggested that data values for these parameters were spread out. The present study not only aims to determining the level of pollution but also aims at identifying its gradient along the different sampling sites along the course of the river and therefore estimates the contribution of each city towards.

Key words: Statistical analysis, physicochemical assessment, Water Quality, Yamuna River, ANOVA.

INTRODUCTION

Anthropogenic activities viz., rapid population growth, urbanization, industrialization and agricultural runoff resulted in increasing river stress and pollution, is worldwide current environmental issue in research (Ouyang, 2005 and Shrestha and Kazama, 2007). The River Yamuna, the largest tributary of River Ganga has been one of the most prominent and important rivers of India (Negi, 1991). River water has been used as drinking water and in irrigation for farming and culturing of fish. It also helps in maintaining the soil fertility, transportation, forest resources development and wildlife conservations. Therefore, comprehensive river water quality monitoring program is becoming a necessity in order to safeguard public health and

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to protect the valuable and vulnerable freshwater resources (Kannel *et al.*, 2007). River Yamuna, one of the most polluted river in the world, receives 85% of pollution from industries and domestic sewage which make it unfit for drinking, swimming and fisheries (Shrivastava *et al.*, 2001). Central Pollution Control Board (CPCB) reported that 70% pollution in river is from untreated industrial and sewage sources and 30% is from agricultural waste and garbages. Hence placed the quality of Yamuna river water under category "E" (CPCB, 1986). It was also reported that there were 2.5 times increment in Biological Oxygen Demand load between year 1980 and 2005 (CPCB, 1986). During the last few decades there has been increasing demands for monitoring of water quality of major rivers by regular measurements of various water quality parameters (Wolman 1971; Steel *et al.*, 1974; Lettenmaier *et al.*, 1977). Several qualitative and quantitative aspects were considered in the analysis of the data. Consequently, various statistical approaches were designed for trend analysis (Hirsch *et al.*, 1982; McLeod *et al.*, 1983; Hirsch and Slack, 1984; Fox *et al.*, 1991; Zetterqvist *et al.*, 1991; Mattikalli *et al.*, 1996). These methods range from descriptive and exploratory studies of tendencies to confirmatory trend analysis.

The river receives all sorts of effluents without any prior treatment from towns situated on its sides. In view of the above, there is an urgent need for accurate and reliable estimate of river water quality for effective management of river basin and thereby taking adequate measures to keep river Yamuna either free from pollution or to keep the concentration of various pollutants under controlled permissible limits.

The objective of this study was to analyzed physicochemical parameters of surface water at six sampling stations of Yamuna River in and around Mathura-Agra region, Uttar Pradesh, India. The generated data set were then subjected to multivariate statistical analysis to evaluate the strength of relationship among the parameters, similarities and dissimilarities between sampling sites and variables.

MATERIALS AND METHODS

Study area

Mathura and Agra situated in north India, 160 km south of Himalayas. Agra Situated in the extreme southwest corner of Uttar Pradesh, Agra 27.1800°N, 78.0200°E. Mathura the birth place of Lord Krishna, is situated in Uttar Pradesh on the west of the river Yamuna 27.4925°N, 77.6736°E.

Sample Collection

Water samples were collected from the six targeted sampling sites of study area of Yamuna River, thrice in a month from Dec 2013-Feb 2014. A total of 54 field samples were carried out for the present study. The brief description of sampling sites is summarized in Table 1. These samples were collected in sterilized bottle and stored at 4ºC. The glasswares were acid washed and rinsed with distilled water before collection of sample.

Analytical Methods

Water samples were analysed for level of pH, temperature, total dissolved solids (TDS), electrical conductivity (EC), total suspended solid (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total hardness (TH), Chloride (Cl^-), total Alkalinity (t-A), phosphate($PO4^{3-}$), nitrate (NO^{3-}) and sulphate ($SO4^{2-}$) by following the method describe by APHA (1998). Detail methodologies are summarized in table 2.

Multivariate statistical procedure

The mean value of three sets of data of water quality parameters in the month of December, January and February from six sampling sites were used for multivariate statistical evaluation. Determination of association, i.e. correlation

Table 1: Details of Sampling Sites

S.No.	Sampling Sites	Locations and probable source of pollution
S1	Kesi ghat	Upstream Mathura (agricultural runoff)
S2	Vishram ghat	Mid stream, a minor sewage drain outfalls into the river directly at this ghat and large amounts of solids get deposited on the river banks
S3	Gokul downstream	Downstream (city's waste along with industrial discharge)
S4	Poiya Ghat	Upstream Agra (domestic waste water)
S5	Belanganj	Mid stream (domestic and house hold industries effluents)
S6	Tajmahal	Downstream (domestic waste and industrial discharge)

Table 2 : Water quality parameters, units and analytical methods used for Yamuna River.

Parameter	Abbrevation	Units	Analytical Methods	Instrument/Make
Temperature	Temp.	°C	Instrumental	Thermometer
pH	pH		Instrumental	pH meter (model pH -538)
Dissolved Oxygen	DO	mg l^{-1}	Wrinkler method	Titration assembly
Biochemical Oxygen Demand	BOD	mg l^{-1}	5-day incubation, 20^{0}C	BOD incubator and Titration assembly
Total Hardness	TH	mg l^{-1}	Titrimetric	Titration assembly
Total Alkalinity	t-A	mg l^{-1}	Titrimetric	Titration assembly
Chemical Oxygen Demand	COD	mg l^{-1}	Potassium dichromate oxidation	Refluxing assemble
Phosphate (Shimazdu, UV-1650PC)	$PO4^{3-}$	mg l^{-1}	Stannous-chloride	UV-VIS spectrophotometer
Nitrate (Shimazdu, UV-1650PC).	NO^{3-}	mg l^{-1}	Phenol disulphonic method	UV-VIS spectrophotometer
Sulphate (Shimazdu, UV-1650PC).	SO_4^{2-}	mg l^{-1}	Turbidimetric	UV-VIS spectrophotometer
Electrical Conductivity	EC	μS	Instrumental	Systronic conductivity meter (Model 306)
Total dissolved solids	TDS	mg l^{-1}	volumetric analysis	Evaporation method
Total suspended solids	TSS	mg l^{-1}	volumetric analysis	Evaporation method
Chloride	Cl^-	mg l^{-1}	Titrimetric	Titration assembly

between phenomena, is an important tool in experimental study. The correlation co-efficient 'r' was calculated to know the relationship in between and among the parameters by using the formula given by Patil and Patil, (2010) and the data obtained was analyzed by one-way ANOVA, using SPSS (ver.16.0).

Where, X and Y represents two different parameters, N= Number of total observation.

RESULT AND DISCUSSION

Water quality variables

The results of water quality parameters of River Yamuna from six sampling sites are portrayed in table 3. Temperature plays a very significant role in maintaining physiochemical and biological activities of aquatic life. The temperature of various locations was within the permissible limits and it is in the ranged of 25°C-28°C. If the temperature increases above the permissible limits, the level of dissolved oxygen decreases and results in diminished aquatic life (Singh *et al.*, 2005; Joshi *et al.*, 2001).

Biological oxygen demand varied from 12 mg l^{-1} - 28mg l^{-1} was found quite higher than the permissible range given by CPCB/WHO/BIS. The higher values of BOD at Agra and Mathura upstream, midstream and downstream could be due to the mixing of organic sewage from their respective townships and industrial waste from the different industries situated in the cities like silver polishing, sari printing and leather industries. Similar finding have been reported by Kumar and Sharma (2004).

Table 3 : Statistical analysis of physicochemical parameters of Yamuna water by one-way ANOVA in Mathura-Agra region.

S. No.	Parameters	Agra-Mathura Region						WHO/CPCB/BIS
		S1	S2	S3	S4	S5	S6	
1	Temp.	25	27	27	28	26	27	-
2	BOD	22.5	12	26	24	28	13.33	>=2
3	TH	510	345	320	290	245	190	300-600
4	pH	7.2	7.43	7.45	7.6	7.4	7.42	6.5-8.5
5	DO	6.44	6.88	5.55	6.66	12	7.33	<6
6	COD	234.6	64.96	64.8	72.22	56.64	107.84	>=10
7	TSS	460	450	445	475	3060	400	45
8	PO_4^{3-}	66	60.4	63.2	73.2	67.6	83.6	0.5
9	SO_4^{2-}	78.4	57.2	56.8	145.4	130.6	110.56	150-400
10	EC	1200	900	900	1000	1000	950	2000
11	NO^{3-}	46.4	51.2	41.4	58.06	43.13	22.92	45
12	Cl^-	125.23	172.45	239.87	236.87	290.57	398.45	250
13	TA	96.67	66.67	66.67	76.67	70	50	200-400
14	TDS	500	350	275	345	780	760	500-2000

The total hardness (TH) was ranged from 190mg l^{-1} - 510mg l^{-1} in Mathura-Agra region which was considered under permissible range of CPCB/WHO/BIS. The careless discharge of industrial effluents and other wastes might be contributed greatly to the poor quality of the water (Singh *et al.*, 2005). Similarly, Khadse *et*

al., (2008) reported a higher range (142– 204 mg l^{-1}) of TH in river Kanhan and Pench due to mixing of urban runoff.

The pH of water sample measures its acidic and basic nature. The pH indicates the alkaline or acidic behavior of water. The pH was ranged from 7.2- 7.6 with moderate alkalinity but it was under the permissible limits given by CPCB/WHO/BIS. The maximum value of pH was recorded at sampling site S4 (pH=7.6) and minimum at sampling site S1 (pH= 7.2) which is suitable for aquatic life. pH of Yamuna river was also determined by Gupta *et. al.*, (2013).

Dissolve oxygen, an essential parameters for water quality reflects degree of pollution load in water bodies. At sampling site S3 in Mathura, low DO (5.55 mg l^{-1}) content was observed which indicated the presence of mild - high organic pollution and toxic wastes in water from sewage of the cities as well as effluents from industries situated upstream of the river. The influxes of organic pollutants into river which is one of the causes for low DO content in water was also reported by Kumar and Sharma (2004). Chandra *et. al.*, (2012) found dissolved oxygen content 5 mg l^{-1} in porur lake, Chennai; 2 mg l^{-1} in hussain sagar lake, and 6 mg l^{-1} in vihar lake Mumbai.

The chemical oxygen demand indicates organic pollution load in water and gives a measure of the oxygen required to decompose organic compound in water bodies. From sampling sites S1-S6, COD was determined between 56.64mg l^{-1} to 234.62mg l^{-1} which was tremendously higher than the permissible limits. It might be due to urban off and sewage drainage at river sites resulted in detoriation of water quality (Mukherjee *et al.*, 1993; Alam *et al.*, 2007; Khadse *et al.*, 2008). COD level was also found higher in Yamuna river ranged from 3-155 mg l-*1* by Mishra (2010).

The quality of water is also evaluated on the presence of suspended solids (SS) and dissolved solids (DS) which correspond to non filterable and filterable residues, respectively. In the present study, the concentrations of SS varied from 445 mg l^{-1} to 3060 mg l^{-1} in Yamuna River. Such a high concentration of TSS reflects inferior quality of water at all sampling station which might be due to garbage (pooja samagiri) dumping, holy bathing and influx of sewerage. TDS ranged from 275 mg l^{-1} to 780 mg l^{-1} in and around Mathura-Agra was found under permissible limits given by CPCB/BIS/WHO. Gupta *et. al.* (2013) was reported TDS in the ranged of 705 mg l^{-1} - 785 mg l^{-1} in Yamuna river whereas Chandra *et. al.* (2012) measured TDS ranged from 107.1 mg l^{-1} – 935. 8 mg l^{-1} in Vihar lake, Mumbai.

Phosphates play a very important role in maintaining the aquatic life as it enhances the growth of plankton in water and provide food for fish and there by maintains the fish population. In the present study, the phosphate concentration was found 60.4 mg l^{-1} -83.6 mg l^{-1} in Mathura-Agra region which is very high as compared to the permissible limit. Such a high phosphate concentration in Yamuna river water might be attributed to the municipal sewage and industrial discharge resulting in eutrophication leading to algal bloom, low oxygen levels and turbidity in water (Girija *et. al.*, 2007).

The Sulphate (SO_4^{2-}) concentrations ranged from 56.8 mg l^{-1} to 145.4 mg l^{-1} in Agra and Mathura. Though the obtained values of SO_4^{2-} are higher than the values ranged for natural water (2-80 mg l^{-1}). Conductivity is the measurement of dissolved ions present in the water. Conductivity of Yamuna water was significantly different among sampling sites, varying from 900μS-1200μS. High conductivity could be due to the presence of high organic residues in the water which is being formed by high temperature and high pH. Similar observations were also observed by Saswar and Wazir (1998) in Yamuna water. Gupta *et. al.*, (2013) also found electrical conductivity ranged from 990 μmhos – 1285 μmhos in Yamuna River.

The nitrate level in water varied from 22.92 mg l^{-1} to 58.06 mg l^{-1}. The highest concentrations of nitrate were found at sites S1 and S2 in Mathura where as at S4 in Agra. It is mainly due to the agricultural runoff, sewage discharge and industrial effluents. The high nitrate content was also reported by Kumar (2000) and Kosygin *et al.*, (2007) in other Indian rivers.

The concentration of chloride varied from 125.23 mg l^{-1} to 398.45 mg l^{-1} from sampling sites S1 to S6 in Mathura-Agra which was higher than the prescribed permissible limits of CPCB (< 250 mg l^{-1}).

The total alkalinity of water which is depended on carbonates, bicarbonates and hydroxides of Ca, Mg, Na, K, ranged from 50.5 mg l^{-1} to 96.67 mg l^{-1} for targeted sampling sites. All the sampling stations were shown total alkalinity in permissible. Khadse *et al.*, (2008) reported a high range (374-486 mg l^{-1}) of t-A in Nag River which carries sewage water. Chandra *et. al.*, (2012) was found the alkalinity in Vihar lake, Mumbai ranged from 42 mg l^{-1} – 410 mg l^{-1}.

Statistical assessment

Descriptive analysis including mean, minimum, maximum, standard deviations, kurtosis and skewness of the water quality parameters are shown in Table 4. The average value of three sets of data for three months of water quality parameters from six sampling sites were used for multivariate statistical evaluation. Standard deviation gives measure of variability of a sample. Kurtosis refers to degree of flatness and peakedness in a region about mode of a frequency curve whereas skewness is a sign of asymmetry and deviation from data (Parmar, 2013). It can be seen from Table 4, the skewness value was negative for temperature, BOD, pH and nitrate but positive for total hardness, DO,

Table 4 : Basic statistics of water quality variables of River Yamuna in Mathura-Agra.

	Descriptive Statistics					
	Minimum	Maximum	Mean	Standard Deviation	Skewness	Kurtosis
Temp	25.00	28.00	26.67	1.03280	-.666	.586
BOD	12.00	28.00	20.97	6.70931	-.658	-1.739
TH	190.00	510.00	316.67	109.62056	1.100	1.904
pH	7.20	7.60	7.41	.12817	-.566	2.401
DO	5.55	12.00	7.47	2.29311	2.078	4.741
COD	56.64	234.60	100.17	68.25994	2.110	4.513
TSS	400.00	3060.00	881.67	1067.45804	2.446	5.988
PO_4^{3-}	60.40	83.60	69	8.35895	1.194	1.268
$SO4^{2-}$	56.80	145.40	96.49	37.94705	.166	-2.170
EC	900.00	1200.00	991.67	111.43010	1.611	2.958
NO^{3-}	22.92	58.06	43.85	11.89147	-1.053	2.002
Cl^-	125.23	398.45	243.90	95.20202	.611	.564
t-A	50.00	96.67	71.11	15.30045	.609	1.759
TDS	275.00	780.00	501.67	220.51455	.555	-2.038

COD, t-A, TDS, TSS, chloride, phosphate, sulphate and electrical conductivity. Curve was platykurtic for BOD, sulphate and TDS where as leptokurtic curve was shown by temperature, total hardness, pH, DO, COD, TSS, chloride, phosphate, electrical conductivity, nitrate and total alkalinity. High standard deviation values of total hardness, TSS, COD, TDS and conductivity suggested that data values for these parameters were spread out.

The data on correlation matrix of various water quality parameters is presented in table 5. pH showed significant correlation with temperature ($r=0.957$ $P<0.01$). Total hardness showed positive correlation with total alkalinity ($r=0.883$ $P<0.05$). Chloride is significantly negative correlated with total hardness ($r=0.981$ $P< 0.05$). Dissolved oxygen also significantly correlated with total suspended solids ($r=0.963$ $P<0.01$). Chemical oxygen demand significant with electrical conductivity ($r=0.882$ $P<0.05$) and Electrical conductivity was positive with total alkalinity ($r=0.828$ $P<0.05$).

Table 5 : Matrix of correlation among water quality parameters.

	Temp	BOD	TH	pH	DO	COD	TSS	PO_4^{3-}	SO_4^{2-}	EC	NO^{3-}	Cl^-	t-A	TDS
Temp	1													
BOD	-0.204	1												
TH	-0.604	0.12	1											
pH	.957**	0.03	-0.648	1										
DO	-0.276	0.319	-0.404	-0.05	1									
COD	-0.719	-0.046	0.742	-0.804	-0.288	1								
TSS	-0.316	0.525	-0.307	-0.061	.963**	-0.311	1							
PO_4^{3-}	0.269	-0.233	-0.59	0.221	0.078	0.056	-0.096	1						
SO_4^{2-}	0.26	0.319	-0.494	0.433	0.531	-0.184	0.442	0.621	1					
EC	-0.724	0.289	0.685	-0.675	0.041	.882*	0.045	0.024	0.169	1				
NO^{3-}	0.16	0.31	0.463	0.264	-0.103	-0.088	-0.007	-0.607	0.061	0.161	1			
Cl^-	.374	-.136	-.914*	.378	.337	-.429	.222	.793	.473	-.451	0.740	1		
t-A	-0.562	0.442	.883*	-0.487	-0.124	0.666	-0.018	-0.463	-0.06	.828*	0.621	-0.111	1	
TDS	-0.379	-0.037	-0.446	-0.295	0.743	0.098	0.604	0.58	0.489	0.2	-0.64	-0.173	-0.296	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

CONCLUSIONS

In the present investigation, it was found that many parameters such as EC, TSS, Total Hardness, Nitrate, Alkalinity, BOD, chloride and COD and phosphate were high as compared to the permissible limits which indicate high levels of pollution, when compared to the standard. The parameters like pH and dissolved oxygen are in the defined limits. The urban runoff and industrial wastewater discharges in Yamuna were the major threat of river water quality in Mathura-Agra region. Overall, water quality of Yamuna was relatively poor with respect to its use for domestic purposes and irrigation purposes. The city's management is not effective and scientific for the collection and disposal of the city's waste. Even public is equally responsible because of ignorance, indiscipline and unhygienic practices. The results obtained stressed the need for implications of proper management of Yamuna River at the locations where it is needed the most.

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Simulation of Groundwater Table Fluctuations in Krishna Western Delta Using MODFLOW

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ABSTRACT

The study was undertaken in the Krishna western delta to compute the simulation of groundwater table fluctuations using MODFLOW. Groundwater model can play an important role in conducting such studies and analyze the future scenarios. The study area KWD (Krishna Western Delta) is covered between 15o 32´ N latitude to 160 34´ N latitude and 800 09´ longitude to 800 55´ E longitude. The iso-bath maps drawn for these periods also reveal the occurrence of groundwater table contours (b.g.l) found to be similar for the years 2005 to 2007 in KWD. The calibrated model MODFLOW was validated using the observed ground water table fluctuations of the years from 2008 to 2010. The statistical analysis of this validation of these model revealed the percentage error for prediction of pre monsoon periods is found ranging from 0.07 to 0.12 and 0.06 to 0.11 for post monsoon. The Iso-bath maps drawn for the year 2008 to 2010 also revealed a similar pattern of occurrence of ground water table contours, for both observed and predicted values.The validated model was used for prediction of future scenarios of ground water table fluctuations in the increment of 1 year, 3 years and 5 years i.e., for the years 2011, 2012, 2015 and 2020.

Key words: Krishna Western Delta, MODFLOW.

INTRODUCTION

Groundwater represents one of the most important water sources in India and accounts for over 400 km3 of the annual utilizable resource in the country. Due to the highly variable nature of the climate, groundwater has become a popular alternative for irrigation and domestic water use across India. Reliance on groundwater resources is particularly strong where dry season surface water levels are low or where wet season flows are too disruptive to be easily tapped. In addition to being accessible, groundwater quality is generally excellent in most areas and presents a relatively safe source of drinking water for Indians in rural and urban centers (www.india.gov.in).

The total annual replenishable ground water resources of the country have been reassessed as 433 Billion Cubic Meters (BCM) and the net annual ground water availability is estimated as 399 BCM. Existing gross ground water draft as on March 2004 for all uses is 231 BCM per year. The stage of ground water development is 58%. The development of ground water in different areas of the country has not been uniform. Highly intensive development of ground water in certain areas in the country has resulted in over exploitation leading to decline in the levels of ground water and sea water intrusion in coastal areas. There is a continuous growth in dark and overexploited areas in the country.

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Groundwater model can play an important role in conducting such studies and analyze the future scenarios. Groundwater models can reproduce the most important features of an actual system with a mathematical representation. If constructed correctly, the models represent the complex relations among the inflows, outflows, change in storage, and movement of water in the groundwater system and possibly other important features, Models can be used to estimate the response of the system to various development options and provide insight into appropriate management strategies. However, while using the model, one must remember that computer models are reproduction of the actual system. Judgment of water management professional is required to evaluate model simulation results and plan appropriate actions.

MATERIALS AND METHODS

Geographical location

The Krishna Delta Irrigation system is one of the earliest major irrigation projects in Southern India. The study area KWD (Krishna Western Delta) is covered between 15o 32´ N latitude to 160 34´ N latitude and 800 09´ longitude to 800 55´ E longitude. It consists of an ayacut on the river Krishna at the present Barrage site near Vijayawada, Krishna District. The KWD covers 24 mandals (2, 10,000 ha) in Guntur district and 7 mandals (32,000 ha) in Prakasam district in the state of Andhra Pradesh. The location map of Krishna Western Delta is given in Fig 2.1.

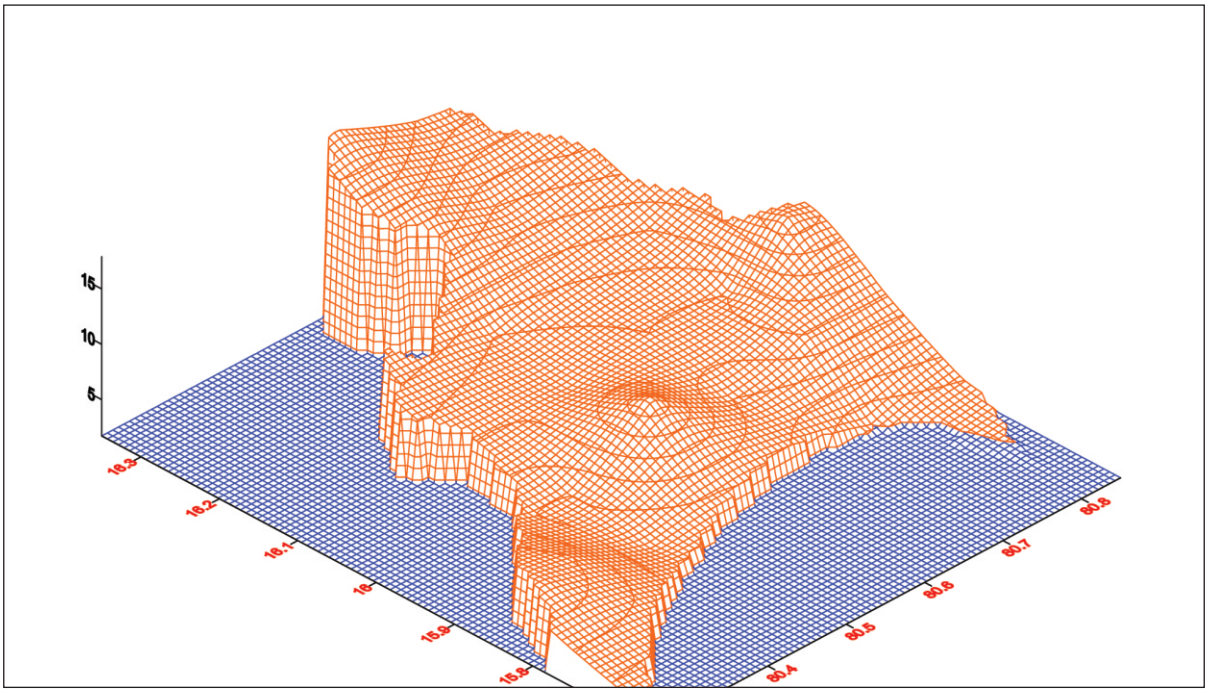


Fig. 2.1: Digital Elevation Model of Krishna Western Delta.

SIMULATION OF GROUNDWATER FLUCTUATIONS IN RESPONSE TO RECHARGE AND WITHDRAWAL

Simulation of a groundwater system refers to the construction and operation of a model whose behaviour assumes the appearance of the actual aquifer behaviour (James W. Mercer, 1980). Model used for this purpose can be a physical or electrical analog or mathematical. A mathematical model is simply a set of equations, which subject to certain assumptions, describes the physical process active in the aquifer. While the model itself obviously lacks the detailed reality of the ground water system, the behaviour of the valid model approximates that of the aquifer. These numerical or mathematical models are deterministic or stochastic in nature.The groundwater models can be broadly classified as 4 types as shown in Fig. 2.2.

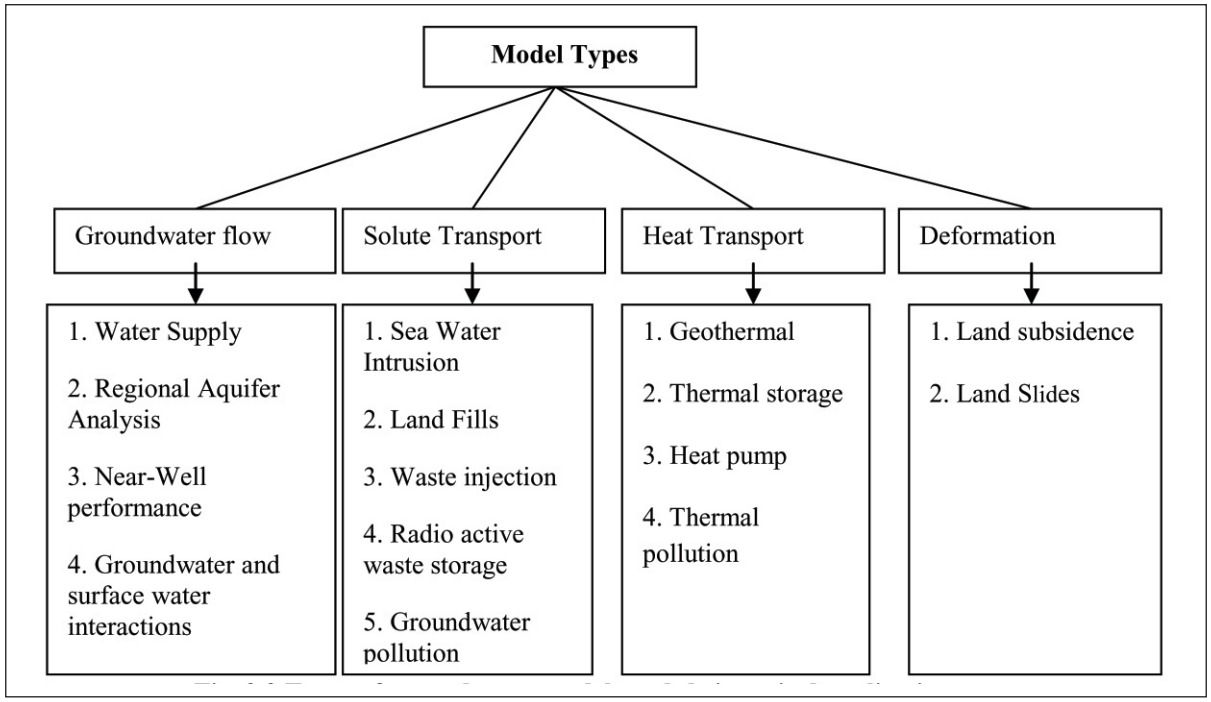


Fig. 2.2 : Types of groundwater models and their typical applications.

Description of the selected Model- MODFLOW

MODFLOW is a modular three-dimensional finite-difference groundwater model developed by U. S. Geological Survey, (McDonald and Harbaugh, 1988). MODFLOW can simulate the effects of wells, rivers, drains, head dependandant boundaries, recharge and evapotranspiration. PMWIN module in this programme supports the calculation of elastic inelastic compaction of an aquifer due to changes of hydraulic heads. MODFLOW simulates the steady state and non- steady flow in the irregularly shaped flow system in which the aquifer layers can be confined or unconfined or a combination of confined and unconfined. Flow from the external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow to river beds, can be simulated. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic and the storage coefficients may be heterogeneous. MODFLOW has the following specific features:

1. It is 2-D or 3-D or quasi 3-D groundwater model.

2. It is simple to use (especially for a USGS code)
3. It is machine dependent specific to UNIX, Mac or PC Fortran compilers
4. It is mathematically efficient
5. The model output is very flexible
6. It has a package to simulate: 1.Specific head 2. Specific flux, 3. Mixed conditions

Method of solving the Ground Water Flow Equations in MODFLOW

The ground- flow equation is solved using the finite – difference approximation. Finite-difference method is defined as the method used to solve differential equations by approximating them as algebraic terms over a grid. The flow region is subdivided into blocks in which the medium properties are assumed to be uniform. The plan view rectangular discretization results from a grid of mutually perpendicular lines that may be variably spaced. The vertical direction zones of varying thickness are transformed into a set of parallel "layers". Several solvers are provided for solving the associated matrix problem; the user can choose the best solver for the particular problem. Mass balances are computed for each time step and as a cumulative volume from each source and type of discharge.

Mathematical dimension of MODFLOW

MODFLOW uses the following equations for groundwater flow simulation.

1. Continuity Equation:

The method of finite differences with block centered approach and solves through the Continuity equation with an assumption that the density is constant and is mentioned below:

$$\Sigma Q_i = SS^{\Delta h} - \Delta V \quad (1)$$

Where,

Q_i = flow rate into the cell (L3/T)

SS = a term equivalent to specific storage (1/L)

V = Volume of the cell (L3), and Δh = change in head over a time interval (L)

2. Darcy's Law:

$$q_{i,j-1/2,k} = KR_{i,j-1/2,k}\Delta c_i \Delta v \frac{\left(h_{i,j-1,k} - h_{i,j,k}\right)}{\Delta_{j-1/2}} \quad (2)$$

3. Finite Difference Model:

$$\frac{\partial}{\partial x}\left[K_{xx}\frac{\partial h}{\partial x}\right] + \frac{\partial}{\partial y}\left[K_{yy}\frac{\partial h}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_{zz}\frac{\partial h}{\partial z}\right] - W = S_s\frac{\partial h}{\partial t} \quad (3)$$

Where,

K_{xx}, K_{yy}, and K_{zz}	=	Hydraulic conductivity along the x, y, and z (L/T)
h	=	Total head (L),
W	=	Sources and sinks of water (1/T),
Ss	=	Specific storage (1/L), and
t	=	Time (T).

Procedure in Simulation with MODFLOW

Discretization of the Area

The study area is descretised according to the variability of the available data. The area is to be divided into rectangular grids as the model is basically of finite difference type. The MODFLOW has the capability to generate the grids or mesh depending on the query of the instructor. The vertical discretization of the area is represented as different layers, which coincides with the heterogeneity of the soil profile in which groundwater flow is simulated. The anisotropy of the layer can be indicated through this option. Each layer can also be represented as unconfined and confined or partially convertible between confined and unconfined. These are some in- built layers types available in the MODFLOW.

i. Type 0	:	The layer is strictly confined
ii. Type 1	:	The layer is strictly unconfined
iii. Type 2	:	The layer is partially convertible between confined and unconfined
iv. Type 3	:	The layer is fully convertible between confined and unconfined
v. Type 4	:	Layer of type 0 + a quasi – 3D confining layer
vi. Type 5	:	Layer of type 1 + a quasi – 3D confining layer
vii. Type 6	:	Layer of type 2 + a quasi – 3D confining layer
viii. Type 7	:	Layer of type 3 + a quasi – 3D confining layer

Boundary conditions

The boundary conditions (Fig. 2.3) of an area is input to the model through the IBOUND array that contains a code for each model cell which indicates whether (1) the hydraulic head is computed (active variable-head cell or active cell), (2) the hydraulic head is kept fixed at a given value (constant-head cell time-varying specific-head cell), or (3) no flow takes place within the cell (inactive cell).It is suggested to use

1	-	For an active cell (Flow boundary)
-1	-	For a constant-head cell
0	-	For an inactive cell (No flow boundary)

For constant-head cell the initial hydraulic head remains the same through the simulation. The initial hydraulic head is specified by choosing starting values initial hydraulic heads from the parameters menu. A constant head boundary exists whenever the aquifer is in direct hydraulic contact with a river, a lake or a reservoir in which the water level is known. It is important to know that a specified head boundary provides inexhaustible supply of water. The groundwater system may get as much water as it needs from the constant head boundary. For a constant

The type of cell is determined as the IBOUND array contains codes for each cell indicating type

1) Head varies with time > 0 (1)

2) Head is constant with time < 0 (-1)

3) No flow cell = 0

0	0	0	0	0	0
0	1	1	1	1	0
0	1	1	1	1	0
0	1	1	1	1	0
0	1	1	1	1	0
0	0	0	0	0	0

Fig. 2.3: The boundary conditions are represented through grid cells to the model.

The cells outside the study domain are represented as inactive cells (Fig. 2.4) and are controlled through IBOUND array in MODFLOW. The input files to the MODFLOW were prepared using Excel and SURFER 7.0 packages which are an efficient means to feed the data to the MODFLOW grid cells, which otherwise will expand the time requirements for simulation.

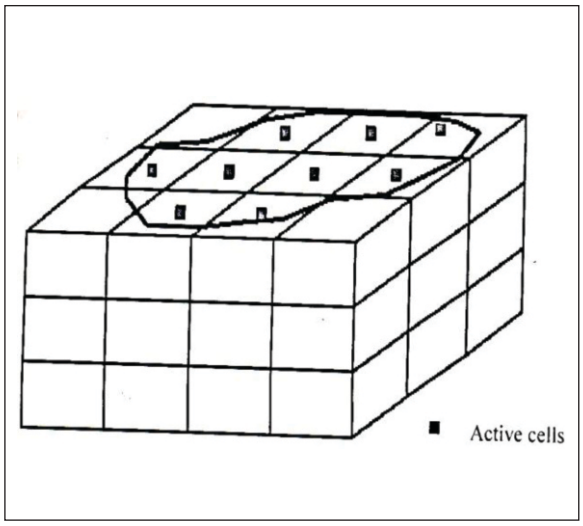


Fig. 2.4 : Descretized part of the area and boundary conditions.

Top of layers

This option takes top elevation of the aquifer as input, but is needed only for layers of type 2 or 3. Top of the layers is required if PMPATH, which shows the flow vectors in the map is used for the simulation. However, if the transmissivity is to be calculated by the model, it demands for the top of the layer data for any kind of aquifer.

The elevations of the aquifer were fed into the model in terms of reduced levels with respect to mean sea level (MSL) i.e. above MSL.

Bottom of the Layers

MODFLOW reads bottom elevation of the aquifers only for layers of type 1 or 3. In general, the bottom elevation of the layer represents the impermeable bed at the bottom of the aquifer and lower limit for the confined aquifers. The bottom elevation of the aquifer was obtained using the average depth of the unconfined aquifer in the simulation area.

Temporal parameters

In MODFLOW, the time domain is divided into stress periods and time steps. Time steps are subunits of stress periods. A solution is computed at each time step. However, the boundary conditions can only change at the beginning of stress periods. In some cases, the boundary conditions only change at discrete points in the simulation and then a small number of stress periods can be used.

When performing a transient simulation, appropriate time steps have to be selected carefully. If the time step is too short, the solution may take forever to compute and we would run out of disk space storing the solution. If the time step is too long, the solution will be less accurate and it may even produce numerical oscillations (the heads change drastically from one time step to the next). But to avoid ambiguity in deciding the time step, a thumb rule is available as mentioned in the equation from below to get a reasonable guess at a time step increment, but it does not assure the accuracy of the output results.

$$\Delta t = \frac{Sa^2}{4T} \quad 4$$

Where,

Δt = the time step increment (T)
S = Storage coefficient
a = representative cell dimension in X and Y (L_2)
T = Transmissivity (L^2/T)

For each stress period the parameters associated with head – dependent boundary conditions in the river, stream, drain, evapotranspiration, general head boundary and time – variant specified – head boundary packages, as well as recharge rates and pumping rates in the well can be changed. However, the length of stress period is not relevant to steady state simulation.

In the present study the interest is on simulating the watertable fluctuations for the pre-monsoon and post -monsoon periods, which invariably define two stress periods, namely, pre-monsoon and post-monsoon. Each stress period is further divided into monthly time steps i.e. each stress period was divided into 6 time steps. In the present study, the first stress period represents from January to June and the second stress period represents from July to December.

Horizontal hydraulic conductivity

In MODFLOW horizontal hydraulic conductivity is the hydraulic conductivity along model rows. It is multiplied by an anisotropy factor to obtain the hydraulic conductivity along model columns. This data can be obtained from the field auger hole tests.

Vertical hydraulic conductivity

For flow simulation involving more than one layer, MODFLOW requires the input of the vertical transmission or leakage term, known as vertical leakance between two model layers. But the software takes the vertical hydraulic conductivities and thickness of layers to calculate the vertical leakance.

Specific Yield

In transient flow simulations, MODFLOW requires dimensionless storage terms specified for each layer of the model. But for steady state, these menu items are not used. In an unconfined layer, the storage term is given by specific yield or unconfined storativity. Specific yield is defined as the volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in the water table. In the present study, for the simulation of watertable fluctuations 12% specific yield was taken.

Effective porosity

Effective porosity is virtually equal to the specific yield when the compressibility is ignored. This parameter is used in the MODFLOW to calculate the average velocity of flow through the porous medium.

Time dependent flow component packages

The following packages account for the groundwater flow in MODEFLOW. They are time dependent input to the MODFLOW to consider the time varying phenomenon in the groundwater system.

1. Well (WELL): This package adds terms to representing flow to wells to the finite-difference equations. In MODFLOW, an injection or a pumping well is represented by a model cell. The injection or pumping rates are specified in recharge or discharge (L3/T). Negative cell values are used to indicate pumping wells, while positive cell values indicate injection wells. The injection or pumping rate of a well is constant during a given stress period and is independent of both the cell area and the head in the cell. It is indirectly assumed by MODFLOW that a well penetrates the full thickness of the aquifer. In case the well penetrates through more than one layer, then each layer recharge of pumping rate has to be considered. The total injection or pumping rate will be equal to the sum of the total layer injection or pumping rates.

2. River (RIV): This package adds terms representing flow to river to the finite-difference equations. This is necessary to simulate the flow between an aquifer and a surface- water feature, such as rivers, lakes or reservoirs. For this package, the data needed are

- Hydraulic conductance of the riverbed (L2/ T)
- Head in the river (L) and
- Elevation of the bottom of the riverbed (L)

The hydraulic conductivity of the riverbed in a grid cell is given by the following equation.

$$C_{Riv} = \frac{K.L.W}{M} \qquad 5$$

Where,

CRIV = Hydraulic conductance of the riverbed
K = Hydraulic conductivity of the riverbed material
L = Length of the river within a cell
W = Width of the river and
M = Thickness of the riverbed.

Recharge (RCH): This package adds terms representing areally distributed recharge to the finite-difference equations. Is designed to simulate areally distributed recharge to the groundwater system. Recharge is defined by assigning the following data to the model grid cells.

- Recharge flux (L/T)

In this model, a provision is available to make the recharge applied only to the top grid layer or vertical distribution of recharge or applying to the highest active cell in each vertical column of the model grid cells.

Evapotranspiration (EVT): This package adds ET to the finite-difference equations. This simulates the effects of plant transpiration and direct evaporation in removing water from the saturated groundwater regime. The following data need to be fed to this input package

- Maximum Evapotranspiration rate (L/T)
- Elevation of the ET Surface (L)
- Extinction Depth d (L)

The ET surface elevation is the elevation above which evapotranspiration from the saturated zone is controlled only by factors such as temperature, humidity but not by availability of water.

The point below which, evapotranspiration from the water table is called the Extinction Depth and is nothing but the depth to which the roots of plants extend below land surface. In the model the extinction depths are based on estimates of root depth for given vegetation and with in a particular land use classification. The governing equation (2.6) for calculating the rate of loss per unit surface area of water table due to ET is given by

$$R_{ETi,j} = R_{ETM,j}\left[\frac{h_{i,j,k} - \left(h_{s,i,j} - d_{i,j}\right)}{d_{i,j}}\right] \qquad 6$$

Where,

$R_{ET\ i,j}$ = rate of loss per unit surface area of water table due to ET (L3/T)
$h_{i,j,k}$ = head in the water table cell (L)
$R_{ETMi,j}$ = maximum ET rate (L/T)
$d_{i,j}$ = extinction depth (L)

This package is based on the following assumptions:

1. When water table is at or above the elevation of the ET surface, evapotranspiration loss from the water table is at the maximum ET rate.
2. No evapotranspiration occurs, when the depth of the water table below the elevation of the ET surface exceeds the ET extinction depth
3. In between these two extremes, evapotranspiration varies linearly with the water table elevation.

MODFLOW limitations

Theoretical limitations

MODFLOW simulates saturated flow in which the water is of constant density and in systems in which the hydraulic conductivity can be treated as a constant. It does not simulate solute transport, unsaturated flow, density-dependent flow, or system in which the hydraulic conductivity varies over times because of changes in temperature the accuracy of a MOFLOW simulation is limited both by the accuracy with which the modeller represents the real system and by the discretization of the system. If the real system is represented correctly, a more finely discretized model will tend to be more nearly accurate than a coarsely discretized model. Usually the limiting factor in the accuracy with which a system represented our inability to accurately measure all the variables that go into the model.

Technical limitations

1. Maximum number of layers = 80
2. Maximum number of stress periods = 1000
3. Maximum number of cells along rows or columns = 2000
4. Maximum number of cells in a layer = 2000 x 2000
5. Maximum number of zones in a layer = 40
6. Maximum number of stream segments = 25
7. Maximum number of tributary segments = 10
8. There is no limit for number of well, general head boundary cells, rivers, drains and horizontal flow barriers. .

METHODS FOR ANALYSIS

The following methods were adopted for achieving the objectives of the research.

- Method of Calibration of the model
- Method of Validation of the model
- Method of Sensitivity Analysis of the model

Calibration of the model

This is carried out by comparing the values of variables like Hydraulic conductivity, Effective porosity, recharge rate, specific yield, and storage coefficient are observed in the field as

1. Standard Deviations (SD's):

The following relations are used for calculation of SD's.

$$\text{SD (o)} = \sqrt{\left(\sum_{i=1}^{N}\left(O_i - Obar\right)^2\right)/(n-1)} \quad (7)$$

$$\text{SD (p)} = \sqrt{\left(\sum_{i=1}^{N}\left(P_i - Pbar\right)^2\right)/(n-1)} \quad (8)$$

In which, O & P are observed and predicted values.

O bar & P bar are averages of corresponding values; n is number of values.

2. Co-efficient of Deviation (CD):

$$\text{CD} = \frac{\left\{\sum_{i=1}^{N}\left(O_i - Obar\right)\left(P_i - Pbar\right)\right\}^2}{\sum_{i=1}^{N}\left(O_i - Obar\right)^2 \sum_{i=1}^{N}\left(P_i - Pbar\right)^2} \quad (9)$$

3. Percent Error (PE):

$$\text{PE} = \frac{\sum_{i=1}^{N} P_i - \sum_{i=1}^{N} O_i}{\sum_{i=1}^{N} O_i} \quad (10)$$

4. Root Mean Square Error (RMSE):

$$RMSE = 100 / Pbar \sqrt{\left(\frac{1}{N}\sum_{i=1}^{N}\left(P_i - O_i\right)^2\right)} \quad (11)$$

5. Mean Absolute Error or Average Deviation (ADAE):

$$\text{ADAE: } \frac{1}{N}\sum_{I=1}^{N}(Oi - Pi) \quad (12)$$

Validation of the model

This is carried out by using the observed data from the project field for the period from 2008 to 2011. The predicted parameters were compared with observed values. Simultaneously statistical analysis was also done to find the errors.

RESULTS AND DISCUSSION

Discretization of the Study Area

The continuous study area was discretised into cells in order to enable the model to perform numerical solutions. The simulation study area was descrtized into square grids, which resulted in total of 7 columns x 8 rows amounting to 56 grids. Out of these 31 grids are falling in the study area considered for simulation of watertable fluctuations. The simulated area with grids generated is shown in the fig.3.1. Finally, the results from those grids (18 grids) for which the observed data is available are used for analysis.

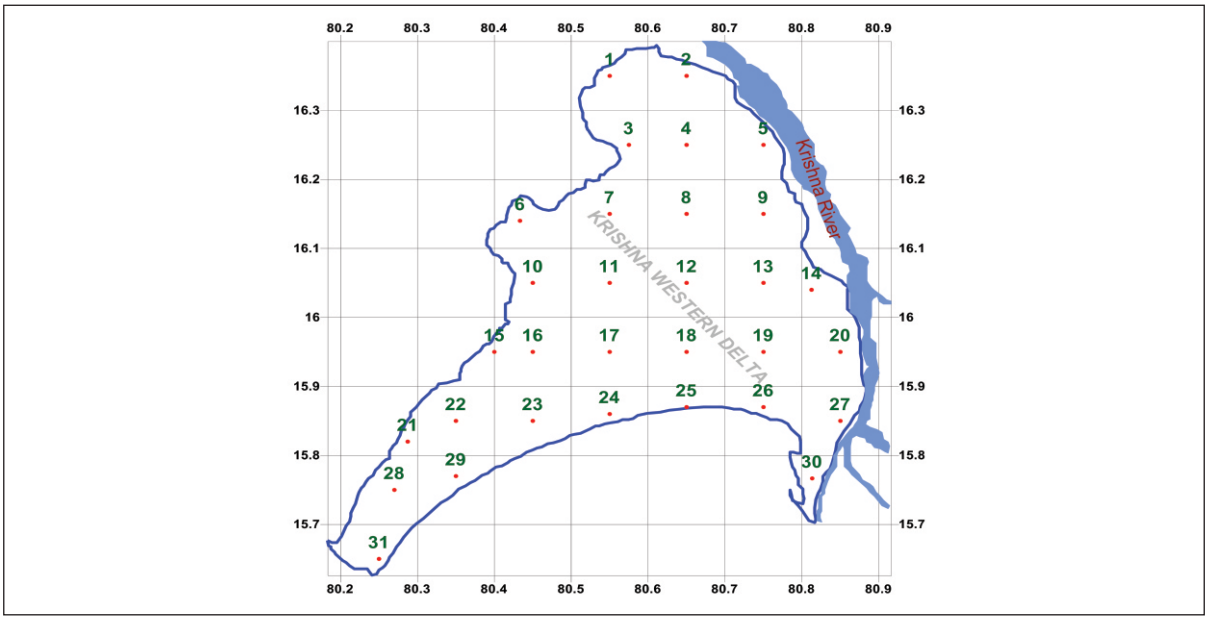


Fig 3.1: The grid map of Krishna Western Delta for simulation of groundwater table fluctuations with longitude and latitudes.

Well draft

The well draft was calculated from the data on number of draft structures and their unit draft. Here, the drafts in both the stress periods were calculated separately as these are not same in both of the stress periods. The total well draft in the given simulation period was estimated to be 1659 m3/d for the first stress period (January to June) and for the rest of the stress period it is considered zero as there was no groundwater use for irrigation of crops during canal flow periods.

Hydraulic conductance

Using the procedure described in the section 2.6 (equation 5), the Hydraulic conductance of canals were estimated and are shown in the table. 3.1. The individual grids through which these canals run were identified and fed the hydraulic conductance only in those grids as to create the effect of canal flow in the study area.

Table 3.1: Hydraulic conductance of five main canals of Krishna Western Delta.

Sl. No.	Canal	K (m/d)	L (m)	W (m)	M (m)	Total Hydraulic Conductance (m2/d)
1	Krishna Western Bank Canal	0.15	74200	12	0.3	445200
2	East Side Channel	0.1	50250	6.7	0.3	112225
3	West Side Channel	0.1	54200	6.7	0.3	121046.7
4	Kommamur Canal	0.1	91600	6.7	0.3	204573.3
5	Appapuram Main Channel	0.1	45000	6.7	0.3	100500

The conductance of the canals flowing the grids were estimated and same was fed into MODFLOW to simulate the effect of canal flow. The following fig. 3.2 represents the hydraulic conductance used for the study in MODFLOW. The rest of the cells were input with zero to represent the non-canal flowing areas.

0	0	0	67418	0	0	0
0	0	0	89892	0	0	0
0	0	0	89892	0	0	0
0	0	0	89892	0	0	0
0	0	89892	0	0	0	0
0	89892	0	0	0	0	0
89892	0	0	0	0	0	0
89892	0	0	0	0	0	0

Fig. 3.2 : The input file of hydraulic conductance in MODFLOW.

Top and Bottom Elevations of the Aquifer

Since the aquifer type is found to be unconfined, the top layer could be assumed as the ground surface elevation. The elevations of the aquifer were fed into the model in terms of reduced levels with respect to mean sea level (MSL) i.e. above MSL. The data is fed to the model only to the cells, which are falling in the groundwater simulation area (Fig. 3.3).

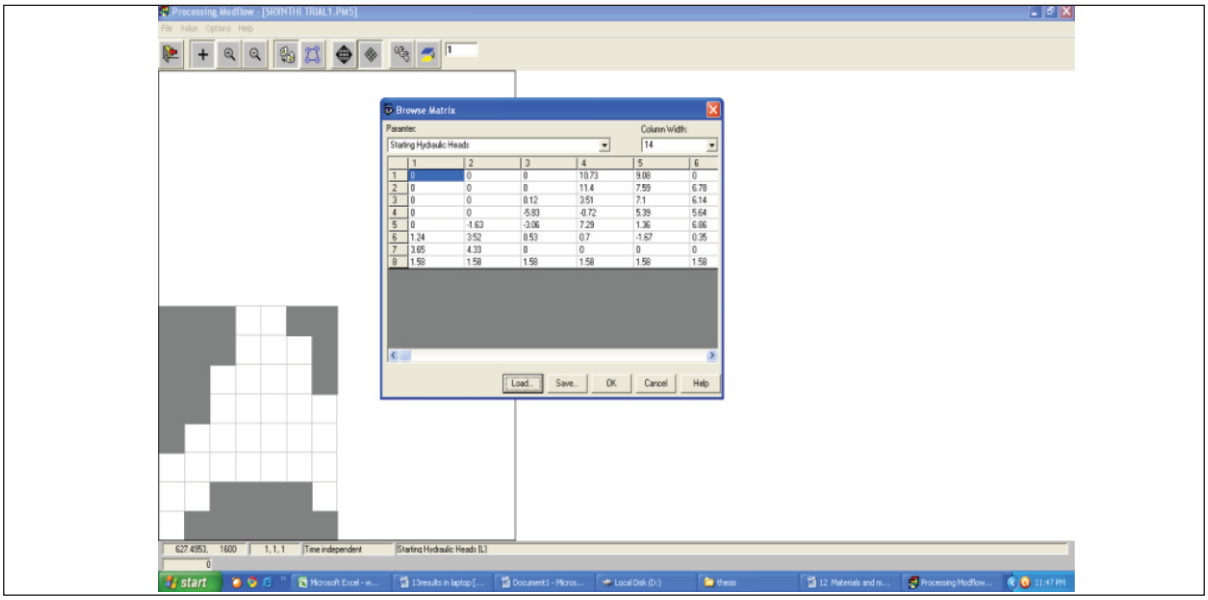


Fig. 3.3: The grid map of Krishna Western Delta for simulation in MODFLOW.

The bottom elevation of the aquifer was obtained using the average depth of the unconfined aquifer in the simulation area. The corresponding reduced levels were calculated and formatted into an ASCII (*.dat) files which were uploaded to MODFLOW software. (Fig. 3.4 & 3.5).

0	0	0	18	15	0	0
0	0	0	13	11	12	0
0	0	8	7	8	9	0
0	0	6	6	7	7	12
0	4	4	9	5	7	7
7	6	3	4	4	2	3
5	5	0	0	0	0	2
3	0	0	0	0	0	0

Fig. 3.4 : Surface elevations (R.L.'s) of individual grid locations in KWD fed into MODFLOW using ASCII (*.dat) files.

0	0	0	-22	-25	0	0
0	0	0	-27	-29	-28	0
0	0	-32	-33	-32	-31	0
0	0	-34	-34	-33	-33	-28
0	4	-36	-31	-35	-33	-33
-33	-34	-37	-36	-36	-38	-37
-35	-35	0	0	0	0	-38
-37	0	0	0	0	0	0

Fig. 3.5: Aquifer elevations (R.L.'s) of individual grid locations in KWD fed into MODFLOW using ASCII (*.dat) files.

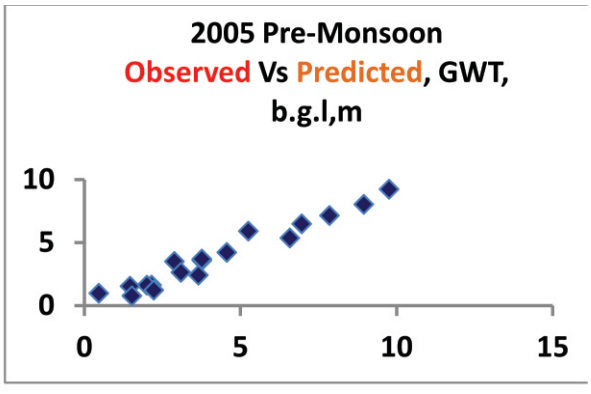
Model Calibration

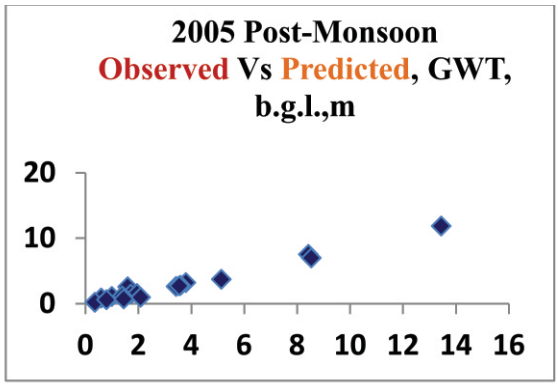
Calibration is the process where model's input parameters are changed to obtain the optimal agreement between the predicted and observed system variables. Calibration of MODFLOW for Krishna Western Delta of Andhra Pradesh was performed by using the observed data set of pilot area from 2005 to 2007 for the both pre-monsoon and post monsoon period. Statistical analysis was carried out to check the reliability of the model performance and showed in Table 3.2.

The statistical measures considered (Table 3.2) indicate that, there was a good agreement between predicted and observed values during the calibration period as indicated by good model efficiency. The values of CD, PE, RMSE and ADAE for calibration period represented good agreement between predicted and observed values. The Percent Error (PE) during the years 2005, 2006 and 2007 of calibration period were 0.10, 0.13 and 0.15 for pre monsoon and 0.09, 0.08 and 0.10 for post monsoon respectively. This indicated a good agreement between observed and predicted values. The values of RMSE indicated that the performance of the model was good in the years of calibration period.

Table 3.2 : Statistical measures of MODFLOW model performance during calibration.

Calibration	2005		2006		2007	
	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
SD(O)	3.92	3.89	3.54	4.45	4.43	3.96
SD(P)	3.69	3.67	3.65	4.20	3.92	3.73
CD	0.99	0.99	0.89	0.99	0.99	0.99
PE	0.10	0.09	0.13	0.08	0.15	0.10
RMSC	46.54	31.42	46.46	35.03	29.64	33.09
ADAE	-0.35	-0.43	-0.42	-0.39	-0.51	-0.44





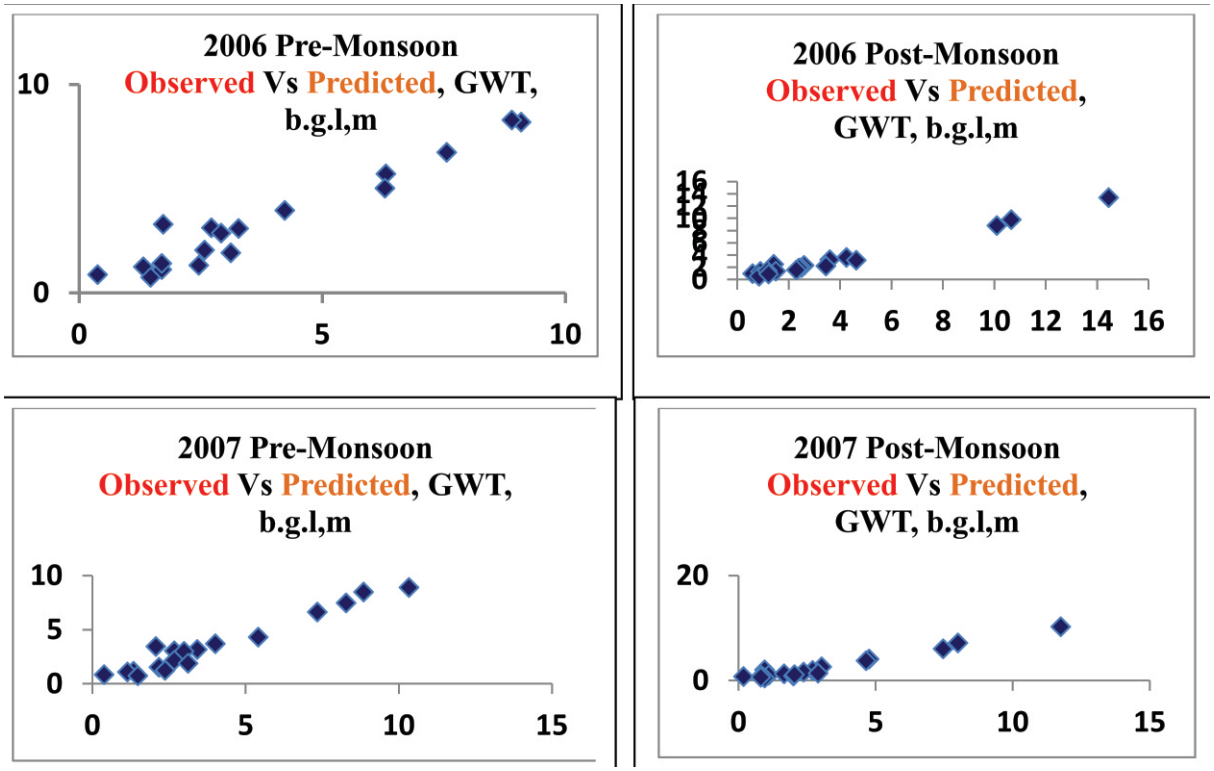
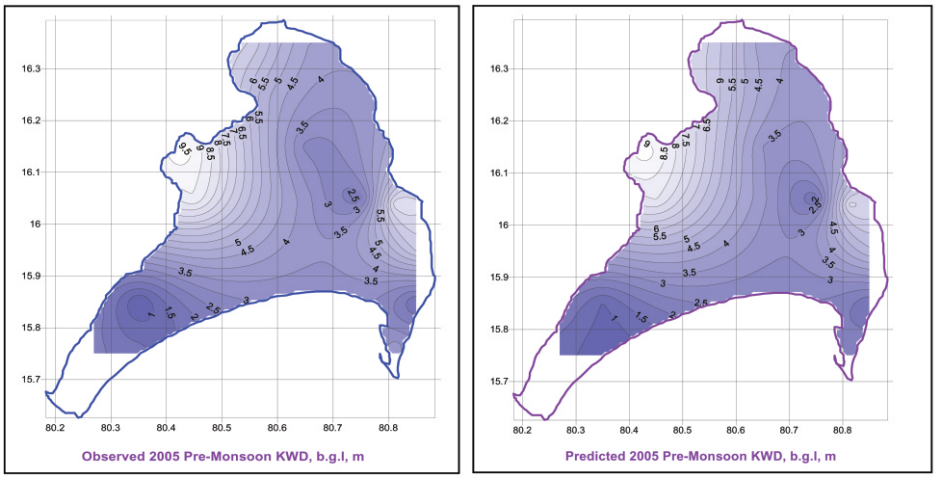


Fig. 3.6 : The observed and predicted groundwater tables in Krishna western delta from the year 2005 to 2007 pre-monsoon and post-monsoon.

In the process of calibration the parameters like hydraulic conductivity and specific yield were modified in order to bring acceptable closeness between observed and predicted in the year 2005, 2006 and 2007 of the groundwater table fluctuations. After calibration, improved performance of the model was observed when the hydraulic conductivity is reduced by 20% and the specific yield was increased by 10%.



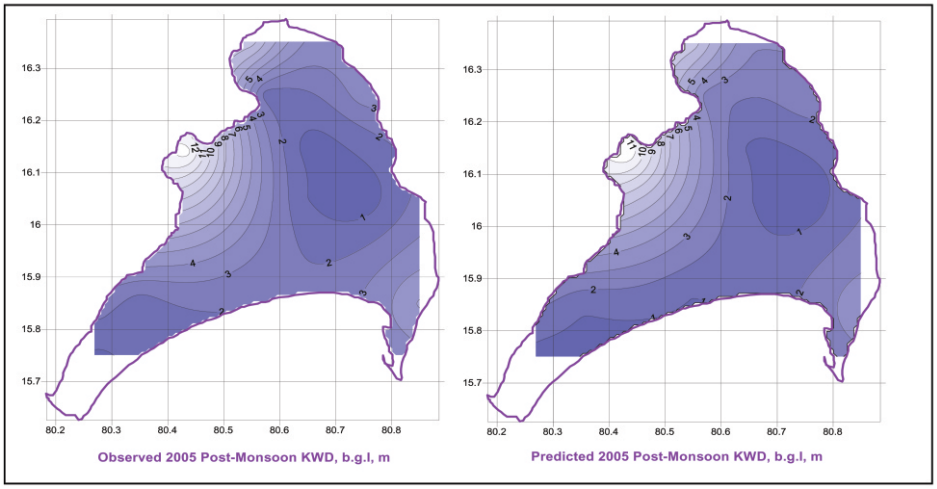


Fig. 3.7: The iso-bath maps of the KWD observed and predicted G.W.T fluctuations for 2005 (Pre & Post- Monsoon).

b.gl., both in observed and predicted as shown in the fig. 3.6, fig. 3.7 & fig. 3.8 for the years 2005, 2006 and 2007 both for the pre-monsoon and post-monsoon respectively using Surfer 7.0 software .

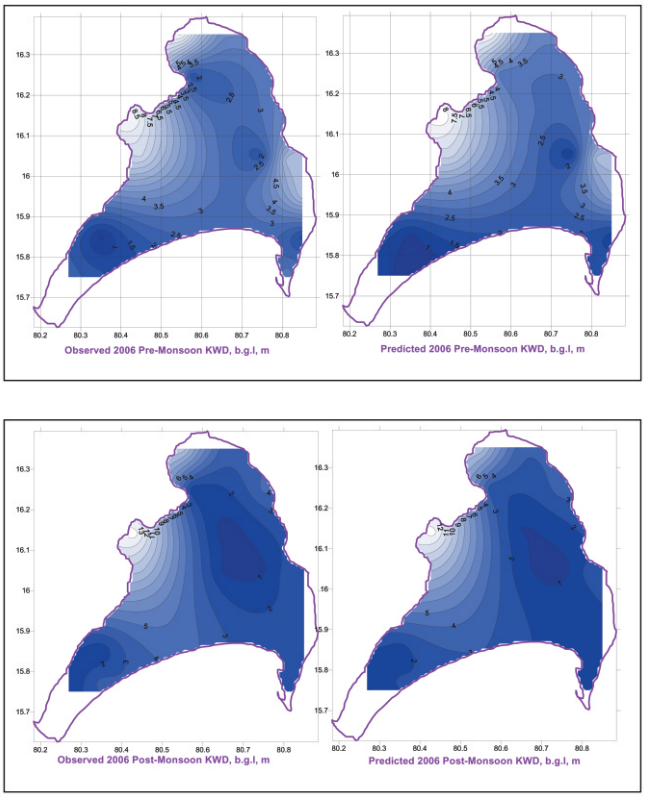


Fig. 3.8: The iso-bath maps of the KWD observed and predicted groundwater table fluctuations for the years 2006 (Pre & Post-Monsoon).

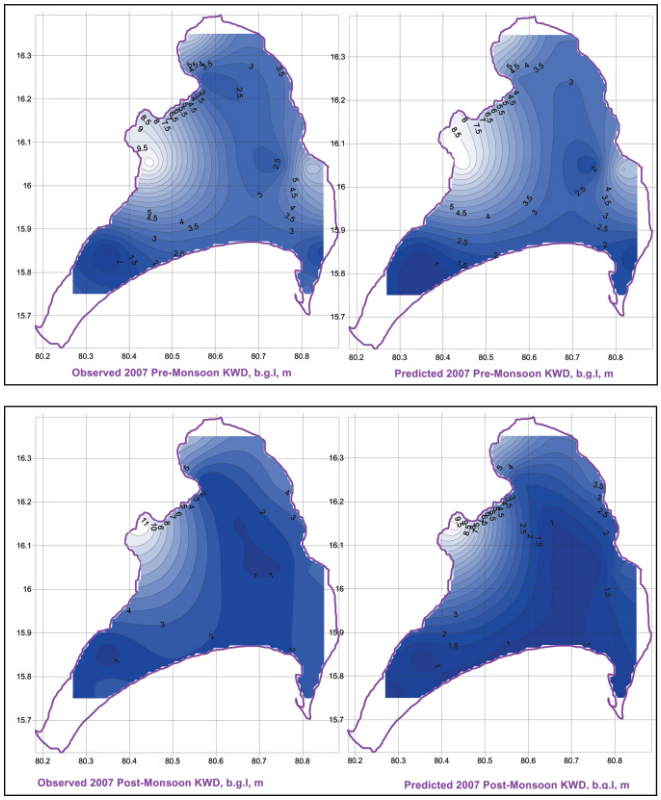


Fig. 3.9 : The iso-bath maps of the KWD observed and predicted groundwater table fluctuations for the years 2007 (Pre & Post-Monsoon).

VALIDATION OF THE MODEL MODFLOW

The calibrated model was validated by comparing the predicted and observed values of the years from 2008 to 2010. The same statistical parameters that were applied during the calibration process were used to test the reliability of model predictions during the validation period.

Table 3.3: Statistical measures of MODFLOW model performance during validation.

Validation	2008		2009		2010	
	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
SD(O)	3.47	4.74	4.29	3.63	4.06	3.61
SD(P)	3.32	4.51	4.10	3.41	3.93	3.53
CD	0.99	0.99	0.99	0.99	0.99	0.99
PE	0.09	0.07	0.12	0.11	0.07	0.06
RMSC	36.62	34.15	43.31	40.46	42.52	38.01
ADAE	-0.40	-0.37	-0.42	-0.43	-0.32	-0.32

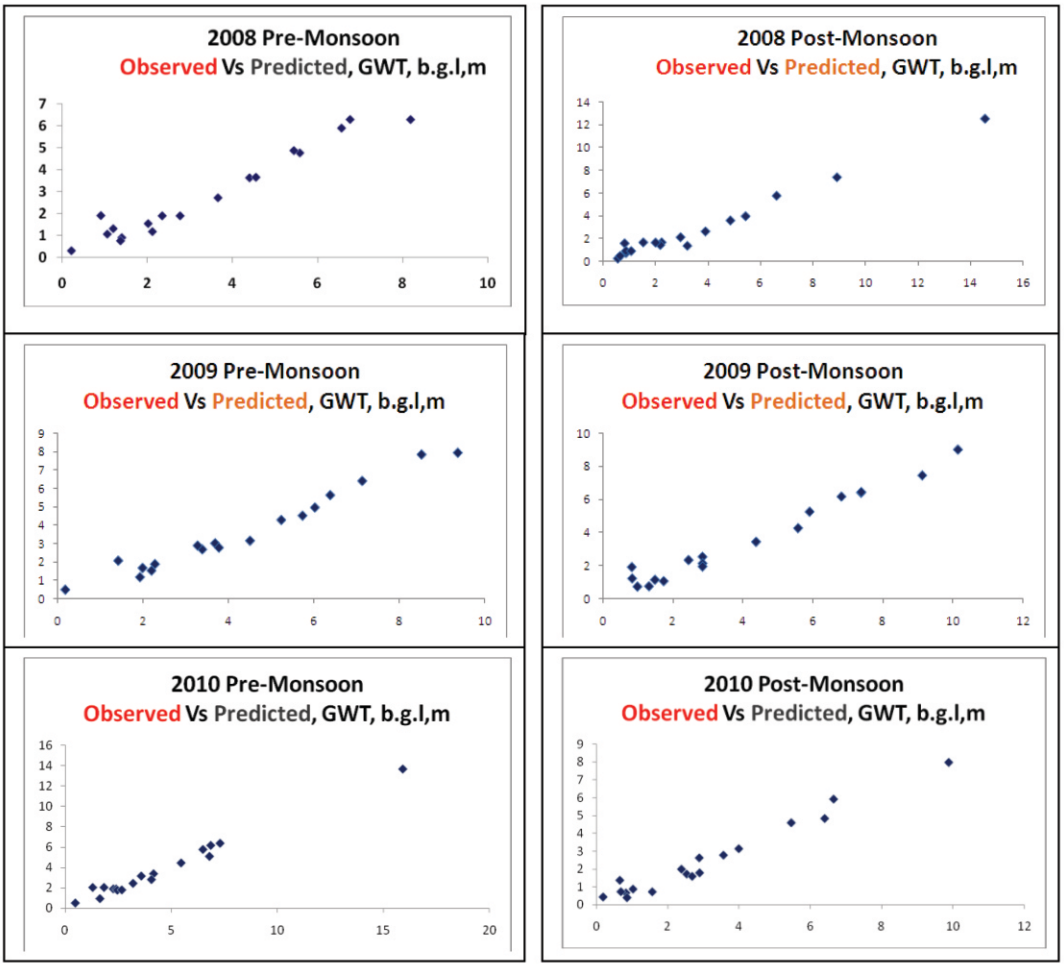


Fig. 3.10: The relationship between predicted and observed data of groundwater tables in Krishna Western Delta for the years 2008 to 2010 (Pre & Post-Monsoon).

The statistical measures considered (Table 3.3) indicate that, there was a good agreement between predicted and observed values during the validation period as indicated by good model efficiency. The values of CD, PE, RMSE and ADAE for calibration period represented good model efficiency. The values of CD, PE, RMSE and ADAE for calibration period represented good agreement between predicted and observed values. The Percent Error (PE) during the years 2008, 2009 and 2010 of calibration period were 0.09, 0.07, 0.12 for pre monsoon and 0.11, 0.07, 0.06 for post monsoon respectively. This indicated a good agreement between observed and predicted values. The values of RMSE indicated that the performance of the model was good in the years of validation period.

The isobaths maps of the KWD were drawn to study the difference in occupancy of contours of various depths to b.gl., both in observed and predicted as shown in the following fig.3.10, Fig.3.11 & fig.3.12 for the years 2008, 2009 and 2010 both for the pre-monsoon and post-monsoon respectively. The predicted values using MODFLOW were used for this after adjusting the hydraulic conductivity reduced by 20% and specific yield increased by 10% was found to be agreeable from the above figures.

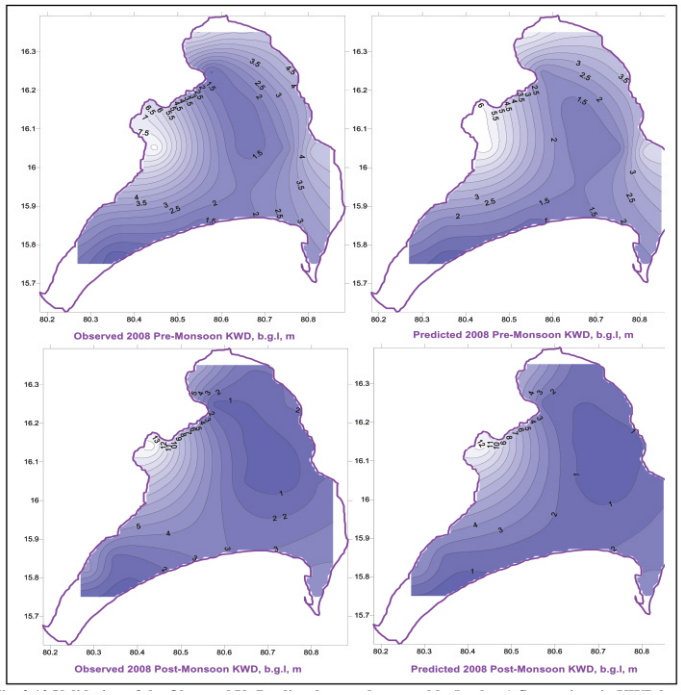


Fig. 3.11: Validation of the Observed Vs Predicted groundwater table (b.g.l., m) fluctuations in KWD both Pre & Post Monsoon for the years 2008.

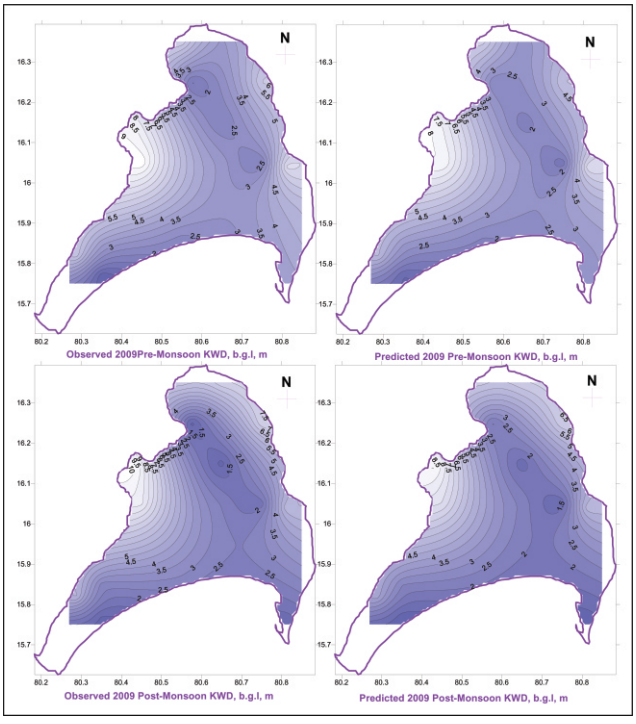


Fig. 3.12: Validation of the Observed Vs Predicted groundwater table (b.g.l.,m) fluctuations in KWD both Pre & Post Monsoon for the year 2009.

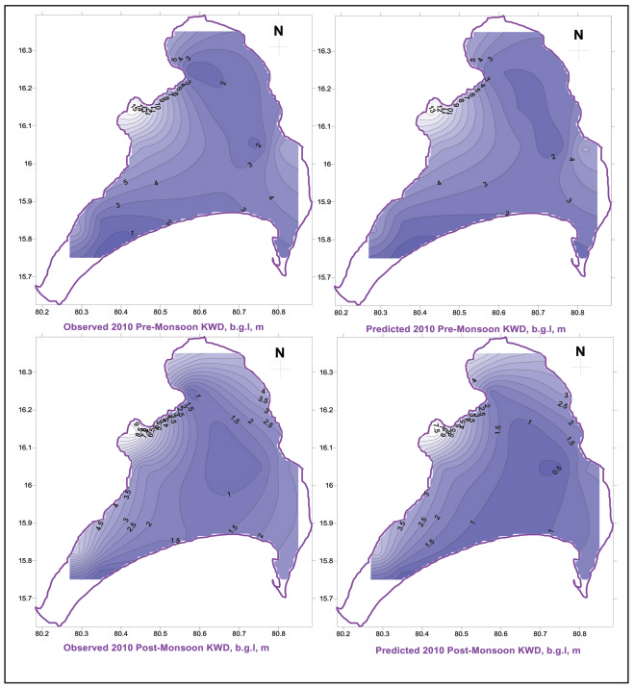


Fig. 3.13: Validation of the Observed Vs Predicted groundwater table (b.g.l.,m) fluctuations in KWD both Pre & Post Monsoon for the year 2010.

After calibration and validation, the groundwater table fluctuations both pre monsoon and post monsoon were predicted for the year 2011 and compared with the observed through iso-bath maps. The statistical analysis reveals that for both observed and predicted, the standard deviation is found ranging between 3.18 to 3.38 both for pre-monsoon and post-monsoon.

Table 3.4: The statistical analysis for the year 2011 (Pre & Post Monsoon).

	Pre-monsoon	Post-monsoon
SD(O)	3.38	3.35
SD(P)	3.18	3.18
CD	0.99	0.99
PE	0.13	0.10
RMSE	42.22	32.60
ADAE	-0.46	-0.45

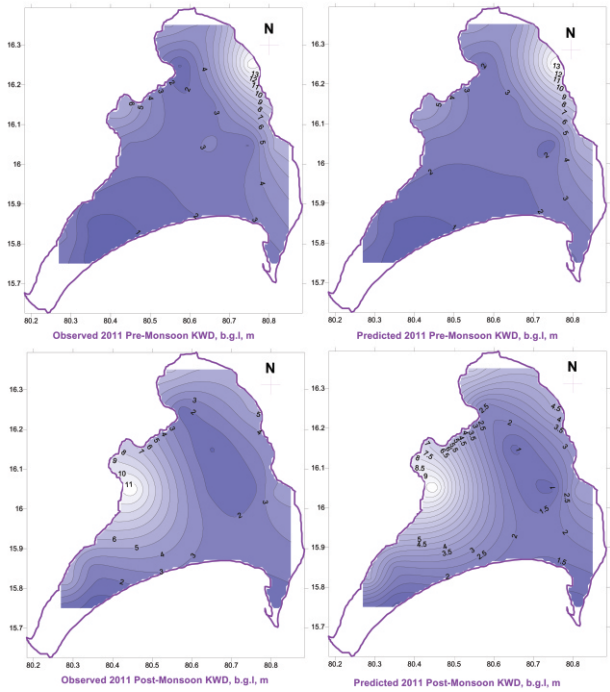


Fig. 3.14: Relationship between Observed and Predicted groundwater table depths (b.g.l., m) for Pre-Monsoon and Post-Monsoon for the year 2011 (after calibration and validation).

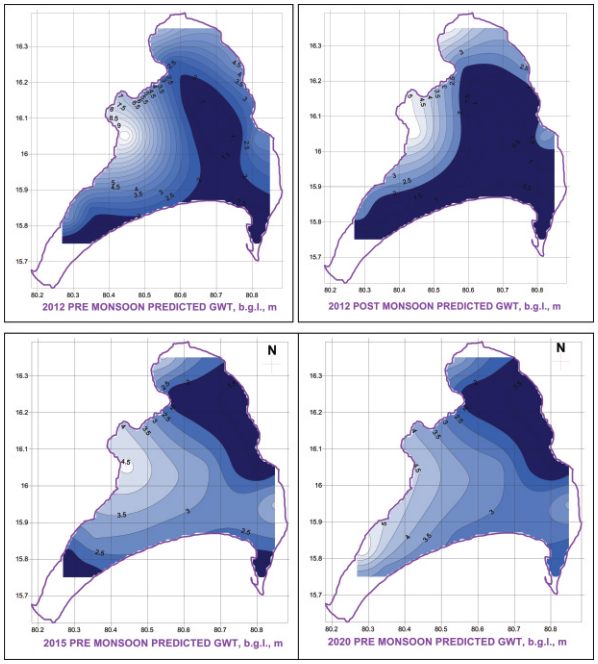


Fig. 3.15 Predicted future scenarios of groundwater table fluctuations for the year 2012, 2015 and 2020.

The above results reveal that the model MODFLOW as a module in PMWIN is performing in the acceptable manner in simulation of groundwater table fluctuations in a given environment, if the parametric input is errorless. After training the model and gaining the confidence through analysis of groundwater table fluctuations both observed and predicted for pre and post monsoon periods, an attempt for estimation of the future groundwater table fluctuations for the years 2012, 2015 and 2020 was carried out and the results are presented through the following figure 3.15.

CONCLUSIONS

Simulations were done for the years 2005 to 2011. The year was divided into two stress periods with time step of one month pre-monsoon and post-monsoon. Initial watertables were fed into model MODFLOW in all cells in KWD as initial conditions. Recharge from the rainfall was distributed uniformly over the study area and so the groundwater pumping. The river conductance was estimated using hydraulic conductivity of the riverbed material, riverbed thickness river bed width and length of the river in the cell. The cells for which observed data is available were selected to compare the observed and predicted water table fluctuations. Groundwater table fluctuations for the years 2005 to 2020 were simulated using MODFLOW. The results of the model were in close agreement with the observed groundwater tables and they were discussed in the section.

Based on the results of the study following major conclusions were drawn:

1. The groundwater model, MODFLOW was used for the prediction for ground water tables which was calibrated using the observed ground water table fluctuations from 2005 to 2007 of KWD.
2. It was found that the model MODFLOW predicted the groundwater table fluctuations in close agreement with the observed ground water table fluctuations when hydraulic conductivity was reduced by 20% and specific yield was increased by 10%. The Percent Error for the pre-monsoon calibration was found between 0.12 to 0.15 and 0.08 to 0.1 for post-monsoon periods. The iso-bath maps drawn for these periods also reveal the occurrence of groundwater table contours (b.g.l) found to be similar for the years 2005 to 2007 in KWD.
3. The calibrated model MODFLOW was validated using the observed ground water table fluctuations of the years from 2008 to 2010. The statistical analysis of this validation of these model revealed the percentage error for prediction of pre monsoon periods is found ranging from 0.07 to 0.12 and 0.06 to 0.11 for post monsoon. The Iso-bath maps drawn for the year 2008 to 2010 also revealed a similar pattern of occurrence of ground water table contours, for both observed and predicted values.
4. The validated model was used for prediction of future scenarios of ground water table fluctuations in the increment of 1 year, 3 years and 5 years i.e., for the years 2011, 2012, 2015 and 2020.
5. The observed groundwater table fluctuation of years 2005 to 2011 and predicted groundwater table fluctuation of 2012, 2015 and 2020 used for delineation of water logged areas.

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International Journal on Environmental Sciences **6** (2) : 249-256, July-December 2015 **Research Article**
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Monitoring of Physico-chemical Characteristics of Municipal Wastewater in Buldana District, India

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ABSTRACT

The physicochemical parameters of the municipal wastewater from Buldana District were assessed from January 2013 to December 2014. The total 15 samples were analyzed during this period. The parameters under study were pH, BOD, COD, Ammonical Nitrogen, Nitrate and Phosphate. The results showed that the values of pH, BOD, COD, Ammonical Nitrogen, Nitrate and Phosphate were varied from 6.8 to 7.52, 61.6 mg/L to 255.67 mg/L, 121mg/L to 720 mg/L, 3.0 mg/L to 146 mg/L, 47.89 mg/L to 217.48 mg/L and 0.26 mg/L to 2.45 mg/L respectively. The study reveals that pH and Phosphate were within the permissible limit. In case of COD, Ammonical Nitrogen and Nitrate some of the values were within the permissible limit whereas some were above the permissible limit. All the values of BOD were above the permissible limit. Hence, municipal wastewater is unsafe and required treatment for domestic, industrial and irrigation purposes.

Key words: Municipal wastewater, BOD, COD, Physicochemical analysis, Ammonical Nitrogen.

INTRODUCTION

Water is known as blue gold because it is one of the priceless gifts of nature. Water is also regarded as the life line on earth it is because of evolution of life and development of human civilization could not have been possible without water (Rangachari, 2005; Biswas, 2007). Out of the total availability of water on earth, very less quantity is available as fresh water (Speidel, 1988). Roughly 99% of water available on earth is not useful for us and only 1% water is available as earth's freshwater for all our day-to-day uses and out of this more than one-third of it is used for agricultural, industrial, and domestic uses (Schwarzenbach, 2006).

The rapidly increasing population, indiscriminate urbanization and rapid industrialization have placed tremendous pressure on the natural water resources and their quality (Sinha and Shrivastava, 1995). Today, because of various anthropogenic activities, the river water usually receives untreated sewage, domestic waste, industrial and agricultural effluents that results in pollution of several rivers in India and abroad. During the last several decades the water quality of the Indian river has been deteriorating due to continuous discharge of domestic sewage (Krishnan *et. al.,* 2007; Duran and Suicmez, 2007; Smitha *et. al.,* 2007). This is one of the most challenging issues facing mankind today (Yelda *et al.*, 2002).

Domestic wastewater is the water that has been used by a community and which contains all the

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materials added to the water during its use. It contains 99.9 % water and 0.1% solids. These solids include 70% organic and 30% inorganic materials. Organic material includes proteins (65%), carbohydrates (25%) and fats (10%). Inorganic material includes grit, salt, metals etc. In addition to these chemical compounds, faeces, urine and many millions of intestinal bacteria and smaller numbers of other organisms. (Duncan Mara, 2004).

The water quality characteristics is denoted by knowing the physicochemical parameters like pH, BOD, COD, Ammonical nitrogen, nitrate, phosphate etc. According to WHO estimate, about 80% of water pollution in developing country, like India is carried out by domestic wastes. The improper management of water systems may cause serious problems in availability and quality of water (Subba Rao and Subba Rao, 1995). The aim of the present study was to analyze physicochemical parameters of municipal wastewater.

MATERIALS AND METHODS

Sampling site and sample collection: The municipal wastewater samples were collected from open drainage from four cities namely Buldana, Chikhli, Khamgaon and Mehkar of Buldana district. The total 15 samples were collected from January 2013 to December 2014, according to standard procedures from American Public Health Association (APHA, 1998). The samples collection time was from 8.00 to 10.0 am at morning. Municipal wastewater sample were collected from about 40-50 cm below the surface, to avoid the collection of surface impurities. Before sampling, 5L polythene bottles were rinsed with 0.1N chromic acid, than washed twice with distilled water. The samples were immediately transferred to the laboratory for physico-chemical analysis. The composite sample was used for analysis consisting of equal quantity of samples from four cities. The analysis was done according to APHA, 1998.

RESULT AND DISCUSSION

In the present study, the physicochemical analysis of wastewater samples collected from Buldana district were carried out during January 2013 to December 2014. The maximum house holding activity is carried out at morning hence the samples were collected at morning. The four samples each from one city (Buldana, Chikhli, Khamgaon and Mehkar) was mixed in equal quantity and used as a composite sample. In present study the physicochemical parameter under study were pH, BOD, COD, Ammonical Nitrogen, Nitrate and Phosphate. The each experiment was performed in triplicate sets. The data was shown in table 1.

The pH of the sample was measured by pH meter. The results of the present study showed that pH of the samples were ranging from 6.8 to 7.52 showed in table 1. These pH values were within the range of permissible limit which is between 6.00 and 9.00. The fig. 1 showed variation in pH during sampling period and suggest that highest pH was observed in December 13 and August 14 whereas at other month the pH of the samples was around 7.0. The high value of pH may because of waste discharge and microbial decomposition of organic matter in the water body (Patil et al., 2012). Very high or low pH has been reported to be toxic effect on aquatic life and alter the solubility of other chemical pollutants as well as some essential elements in water systems (Morrison et al., 2001; DWAF 1996). In present study, pH of all samples was slightly acidic to slightly alkaline whereas Dubey (2013) reported alkaline pH of municipal wastewater.

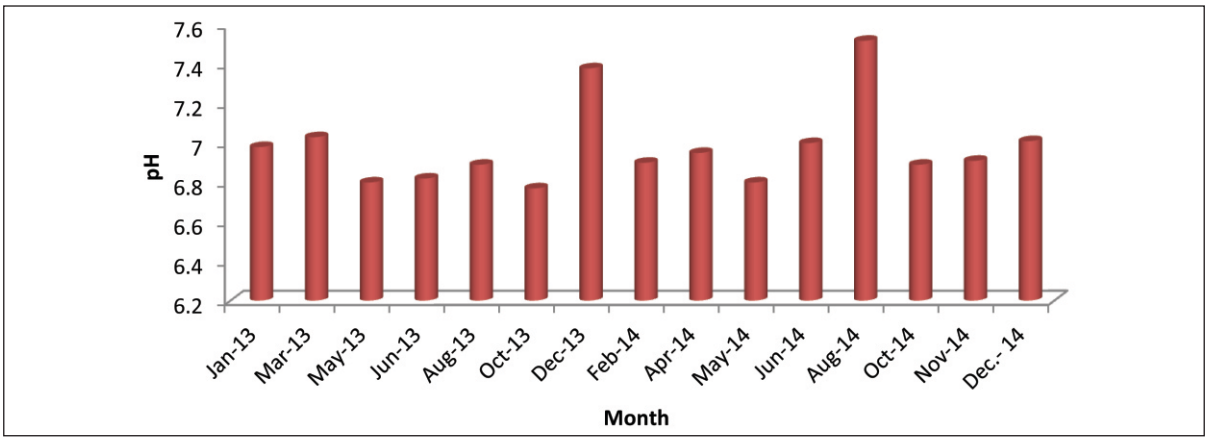

Fig. 1: Graph showing variation in pH.

Table 1: Physicochemical analysis of municipal wastewater from Buldana district.

Sr. No.	Parameters ± SD						
	Sampling Month	pH	BOD (mg/L)	COD (mg/L)	Ammonical Nitrogen (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
1	January 13	6.98±0.02	145±14.93	230±5.77	29±2.66	187±9.54	1.78±0.12
2	March 13	7.03±0.11	120±19.08	200±15.72	146±12.53	83.81±6.85	1.91±0.14
3	May 13	6.8±0.14	168±16.46	348±25.06	50±3.33	181.09±14.76	1.04±0.14
4	June 13	6.82±0.12	72.36±12.02	200±19.16	13±0.5	182.58±18.57	0.65±0.17
5	August 13	6.89±0.08	61.6±5.11	200±20.78	17±4.44	47.89±5.47	1.06±0.16
6	October 13	6.77±0.04	75.33±6.34	212.43±22.12	61±3.64	106.97±11.34	1.23±0.08
7	December. 13	7.38±0.08	125±8.78	484±34.18	55±10.22	194±15.60	2.4±0.17
8	February 14	6.9±0.09	145.25±21.45	283.75±30.5	48±14.33	125.5±10.78	1.53±0.22
9	April 14	6.95±0.11	220±23.90	400±0.0	3.0±0.35	124.22±28.27	0.8±0.21
10	May-14	6.8±0.12	255.67±24.83	720±134.27	41.5±3.29	167.63±8.46	0.26±0.04
11	June 14	7.0±0.17	199.5±36.51	575±82.40	65±16.64	101.8±29.93	1.58±0.25
12	August 14	7.52±0.03	117±5.66	207±18.21	46.57±8.88	128±6.98	1.45±0.12
13	October 14	6.89±0.06	86±7.26	121±10.82	35±6.08	122±3.61	2.1±0.26
14	November 14	6.91±0.01	145±21.0	214±18.33	50±3.61	155.65±10.17	1.23±0.08
15	December 14	7.01±0.02	180±13.45	460±35.36	67.43±11.64	217.48±15.59	1.21±0.05
Permissible limits		6-9	30	250	50	45	5.0

Biochemical Oxygen Demand is the amount of oxygen required for microorganisms to stabilize the organic matter. BOD determines the strength of sewage, effluents and other polluted waters. It is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20^{0}C. The statistical analysis of data was showed in table 1. The

results of the present study showed that BOD was ranging from 61.6 mg/L to 255.67 mg/L. The highest BOD was recorded in summer whereas lowest BOD was recorded in monsoon (fig.2). The entire BOD values were above the permissible limit which is 30 mg/L. Higher contents of organic load are the causative factors for maximum BOD levels (Sonune et al., 2015). Usually the microorganisms require more oxygen to reduce the high organic nutrients present in sewage. In monsoon comparatively lower BOD was recorded due to dilution of the effluent. Similar finding was observed by Dubey (2013).

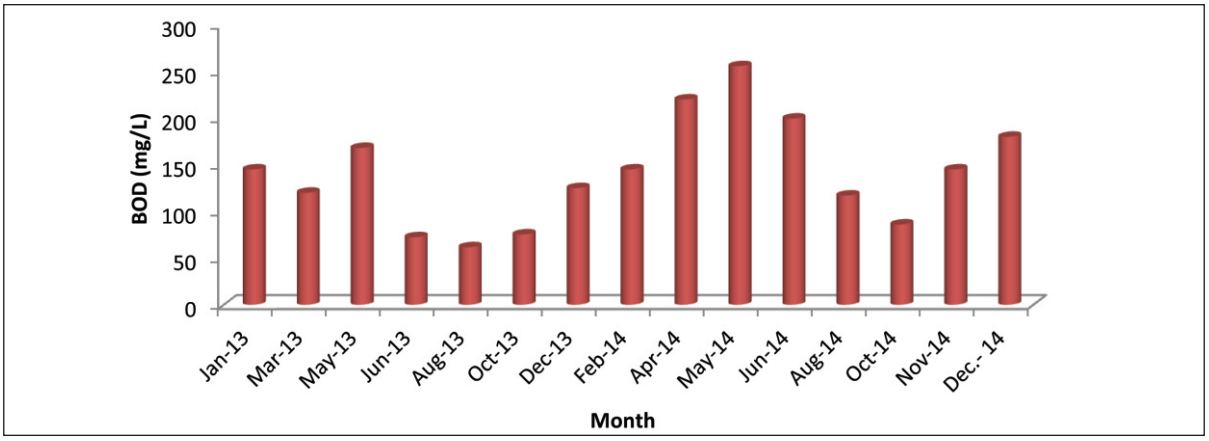

Fig. 2: Graph showing variation in BOD.

Chemical Oxygen Demand (COD) is a measure of the amount of oxygen required by a strong oxidant to break down both organic and inorganic matters in a water system (Akan et al., 2008). The COD values were varied from 121 mg/L to 720 mg/L. Out of the 15 samples, eight sample values were within the permissible limit whereas remaining seven values were above the permissible limit which is 250 mg/L (table 1). The highest COD was recorded in summer whereas lowest COD was recorded in monsoon (fig.3). The organic as well as inorganic compounds have an effect on oxidation of municipal wastewater. COD represents not only oxidation of organic compounds but also the oxidation of reductive inorganic compounds. Elevated levels of COD in wastewater lead to drastic oxygen depletion which adversely affects the aquatic biota (Fatoki et al., 2003). Similarly Wolfgang et. al., (2012) reported high values of BOD, COD and Ammonical Nitrogen.

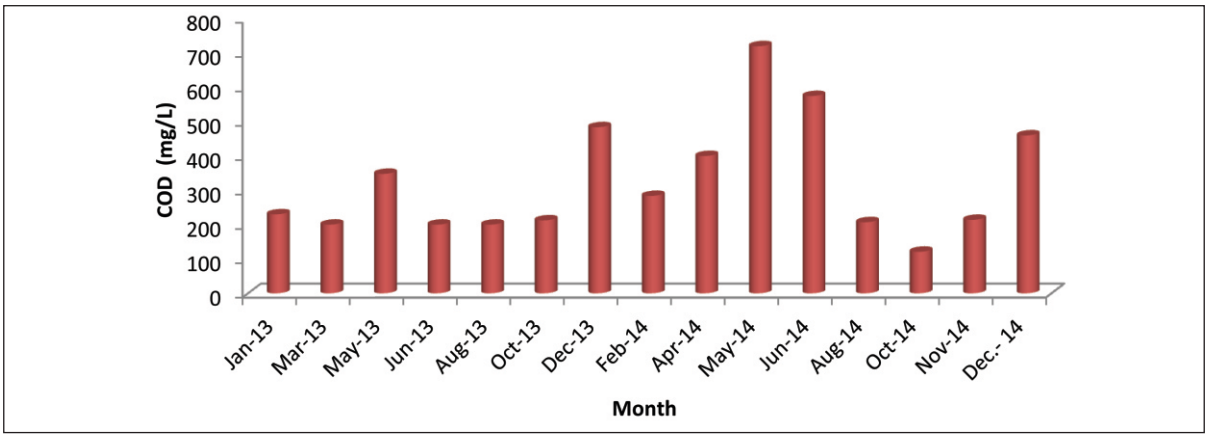

Fig. 3: Graph showing variation in COD.

The minimum concentration of Ammonical Nitrogen was found to be 3.0 mg/L whereas maximum concentration was 146 mg/L (table 1). The highest concentration was observed in the month of March-13, which was due to higher microbial activity. At higher pH, ammonia is toxic to aquatic organisms and also for terrestrial organisms (Princic et al., 1998). Wosnie and Wondie (2014) observed high value of BOD, COD and Ammonical Nitrogen. Similarly Binu Kumari *et. al.*, (2006) also reported high ammonical nitrogen in open drainage municipal sewage water. Das *et. al.*, (2003) reported that high organic pollutant load resulted in marked increase in the concentration of ammonical nitrogen in drains and may be due to decaying organic matter.

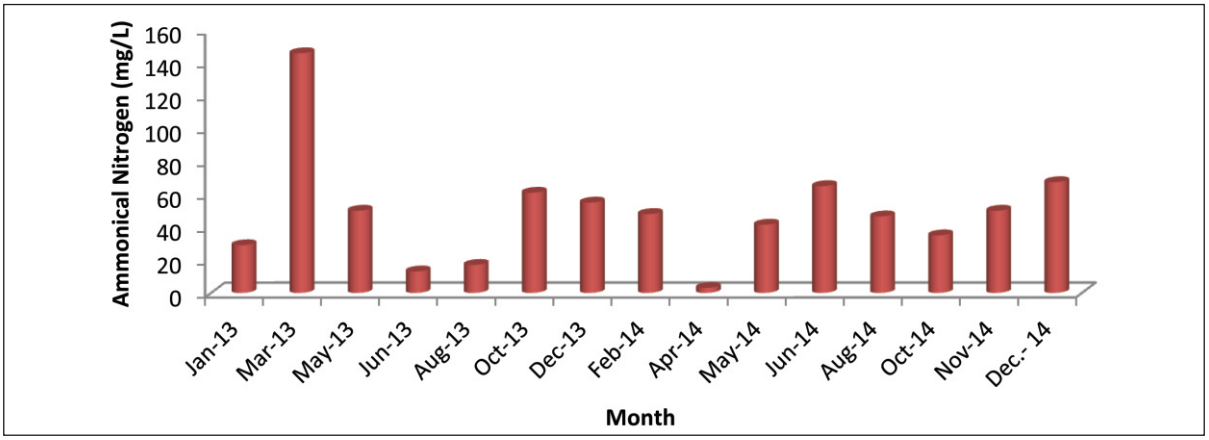

Fig. 4: Graph showing variation in Ammonical Nitrogen.

The results showed in table 1 suggest that nitrate values were varied from 47.89 mg/L to 217.48 mg/L. The concentration of nitrate of all samples was higher than the WHO upper limit of 45 mg/L for domestic water. The fig. 5 showed variation in nitrate concentration during sampling period. Nitrate is inorganic sources of nitrogen that support the growth and development of living organisms at appropriate concentrations. However the high nitrate levels may result in eutrophication that leads to loss of diversity in the aquatic biota (CCME 2006). It has also been reported that high nitrate concentration may result in anemia in infants and pregnant women

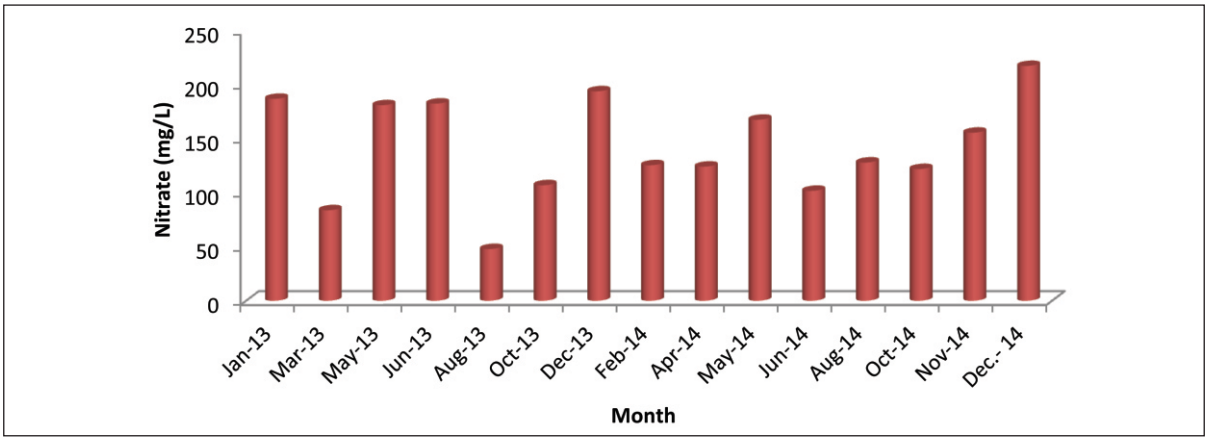

Fig. 5: Graph showing variation in Nitrate.

and formation of carcinogenic nitrosamines (Akan *et al.*, 2007). Singh *et al.*, (2012) found that high concentration of nitrate in wastewater of Dheradun whereas Odjadjare and Okoh (2010) reported slight high nitrate concentration in the effluent than safety limit during summer.

Phosphate is one of the nutrients involved in the eutrophication of water bodies. The concentrations of phosphate were varied from 0.26 mg/L to 2.45 mg/L. The concentration of phosphate in the entire sampling period was lower than the WHO limit of 5.0 mg/L for the discharged of wastewater into river (table 1). Similar results were observed by Sarkinnoma *et al.*, (2013) and Sonune *et. al.*, (2015).

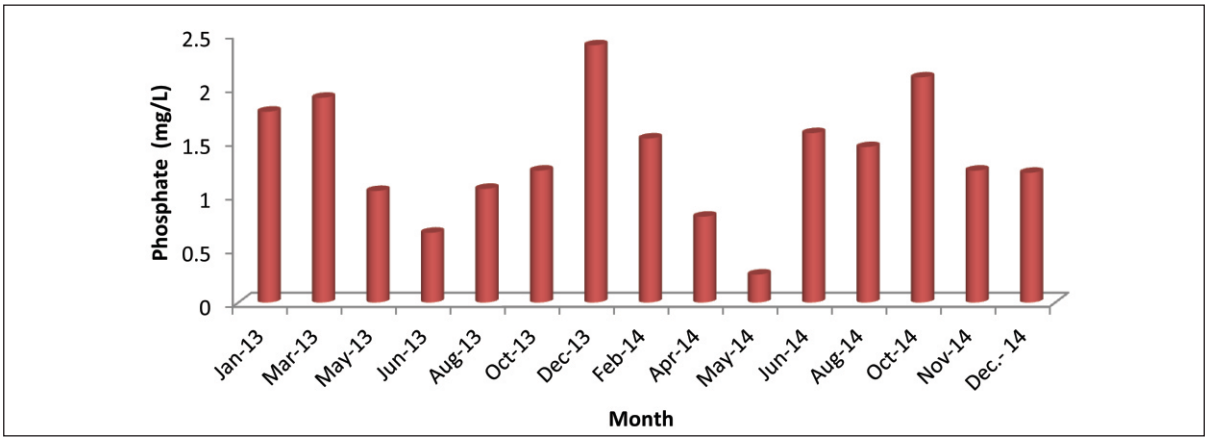

Fig. 6: Graph showing variation in Phosphate

CONCLUSION

In the present study, several physico-chemical parameters of municipal wastewater from Buldana district were analyzed. The results suggest that pH and phosphate were within the permissible limit. The values of BOD, COD, Ammonical Nitrogen and Nitrate were higher than permissible limits. These indicate that municipal wastewater contain high organic load and unsafe for recreational purposes, therefore such wastewater required treatment.

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International Journal on Environmental Sciences **6** (2) : 257-264, July-December 2015 **Research Article**
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A Study on the Rare, Endangered and Threatened (RET) Plants of The River Pampa Banks

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ABSTRACT

A study on the rare, endangered and threatened plants of the river pampa banks were undertaken with special reference to medicinal plants. Endangered species are that have a high likelihood of going extinct in the near future. Rare species are that have small total numbers of individuals often due to limited geographical ranges or low population densities. By the survey 73 Rare, Endangered and Threatened (RET) plants and 11 endangered medicinal plants were identified from Pampa basin. Observations suggest that a good number of medicinally important plants are on the verge of extinction. Strategies for *in-situ* and *ex-situ* conservation were undertaken by planting them in the Botanical Garden of the St. Thomas College and developed a suitable protocol for tissue culture method. Tribal people are consulted to get information in which ways they utilize these plants in their life style.

Keywords: Medicinal plants, Rare, endangered, threatened, exploration, conservation.

INTRODUCTION

India is bestowed with unique diversity in culture and natural vegetation exhibiting rich plant diversity. It has all known types of agro-climatic, ecologic and edaphic conditions. It also has unique biogeographical positions having all known types of eco-systems. It harbors about 17500 flowering plants out of which 2000 plants are used in various classical systems of medicine like Ayurveda, Sidda and Unani. These Indian systems of medicine use predominantly plant materials for the preparation of their drugs. The tribals and other communities used about 8000 species of wild plants as traditional medicine (Pushpangadan, George and Sathish Kumar, 1994). To achieve the goal of health for all there is a need for global movement for conservation of medicinal plants and revitalization of the native health traditions of local communities (Somanadan *et. al*, 1999). The variety of uses and vernacular names which these plants have are an indication of the awareness and knowledge which local communities possess about them. (Kerala Agricultural University, Medicinal plants for home remedies, 2006).

Nearly 95% of the medicinal plants are harvested from the wild. The population growth, urbanization, shrinking forests, over harvesting and related factors has brought several medicinal plants to the very brink of extinction (Arora, 1997). Conservation of threatened medicinal plants is therefore considered to be the most important responsibility of all nations and institutions particularly the biodiversity rich nations (Winfred Thomas et al, 2003). The ministry of Environment and Forests have already banned the collection of 29 endangered species of medicinal plants from their natural habitats (Binu, 2010)

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Pathanamthitta District lies between 09^{O} 05'N latitude and 76^{O}16'E longitude. Topography is highly undulating with hills and valleys. Altitude ranges from 5-1200 m. The lowest is represenred by Tiruvalla and the highest by Kakki hills (1000-1200m).Temperature varies from 24 to 30^{O} in plains and 15 to 32^{O} in the hills. March, April and May are the hottest months whereas December and January are the coldest. The southwest monsoon (June to September) and Northeast monsoon (October to November) provide an average of 714 and 450 mm rain respectively. The District experiences a tropical humid climate and relative humidity varies from 64 to 98%. Forest occupies 64% (1724 sq. km.) of the total area of the district.Tropical evergreen, tropical semievergreen, tropical moist deciduous, sholas and grasslands are the main vegetation types.

The Pampa River is the third largest river in Kerala (176 km) also has the fourth largest catchment area (2235 sq.km), starts from the Western Ghats of Pathanamthitta Dist, flows as a silver line along the heart of the central Travancore, becomes stagnant at the rice bowl of Kerala (Kuttanadu) and falls in the Arabian sea . Pampa River, called the 'Dakshin Ganga', the Ganges of the South, drains through the foot hills of Sabarimala where the World famous pilgrim centre Sabarimala Sree Dharma Sastha Temple, the abode of Lord Ayyappa is located. About 1550 km^{2} of the catchment area of the river is with in Pathanamthitta District .Devotees of Lord Ayyappan believe that immersing oneself in the Pamba is equivalent to bathing in the Holy Ganges River.

We in India have inherited one of the world"s richest treasure stroves of medicinal plants. Diverse climatic and soil conditions have given rise to ten biographic zones, 25 biotic provinces and 4635 ethnic communities, which together are the home of around 8000 species of medicinal plants. (Kerala Agricultural University, Medicinal plants for home remedies, 2006).These plants, referred to over 20,000 vernacular names, are widely used for human, veterinary and agriculture realared applications, but this knowledge is largely undocumented and is in danger of being lost to mankind. In Kerala too, there is a wide diversity of medicinal plant species and several effective herbal remedies for various health problems. The systematic compilation in to a self reliant and self help system would be a boon to the common man. A tremendous passion for the study and use of medicinal plants has always driven our people, and is evident in our folk tradition and literature.Herbal medicines made out of local floral biodiversity are in use in every nook and corner of the country.

River Pampa basin is rich in biodiversity especially medicinal plants. These areas are unexplored and there are no major conservation projects. Anilkumar, Sivadasan and Ravi (2006) studied the Flora of Pathanamthitta District Western Ghats, Kerala and it was published by Daya Publishing house, New Delhi, 2006.The flora presents a systematic account of a 1249 species belonging to 658 genera and 148 families of seed plants.The species index is registered as 460/1000 sq. km. which is comparatively very high and indicates the richness of the floristic diversity of the District. An analysis of the flora showed that 260 species are endemic which formed 22% of the total species. About 200 species are rare, and 175 are severely threatened, most of which are local endemics. They collected 90 wild relatives of cultivated crop plants (Anilkumar *et al.*, 2006).

The most serious aspect of the loss of biodiversity is the extinction of species. A species is considered extinct when no member of the species remains alive anywhere in the world.Once a species is eliminated, the unique information contained in its DNA and the special contribution of characters that it possessed are unlikely ever to be repeated again (Monivannan, 2010). Also, once a species goes

extinct, their chances for further evolution are lost. A species that is found in only a single geographical area and nowhere else is said to be endemic to that area. Endangered species are that have a high likelihood of going extinct in the near future. Rare species are that have small total numbers of individuals often due to limited geographical ranges or low population densities. Species that may become endangered in the near future because populations of the species are decreasing in size throughout its range are vulnerable. Threatened species include those which are endangered, vulnerable and rare in IUCN categories. Hundreds of RET plants in India have already been recorded and their conservation suggested (Jain, 1983). The Red Data Book (Nayar and Sastry,1998) has enlisted 622 vascular plant species of Indian flora till 1990; this red figure rose to 1255 vascular plants till 2003, and it is on the increase day by day (Sanjappa et al 2012). In India, the RET species constitute7.7% of known Vascular plants. Globally, 13.8% of VPS are RET (Rao *et al*, 2003).

MATERIALS AND METHODS

Kochupampa, Kakki, Athikayam, Ayithala, Ranni, Aayikkal, Keekozhoor, Puthumon, Kiliyanikal, Vazhakkunnam, Cherukolpuzha, Melukara, Keezhukara, Kozhenchery, Aranmula are the spots of survey and identification of plants on Pampa river basin extending 100 K.M from Aranmula

Field surveys were conducted once in every two months from June 2011 to May 2013 in the above mentioned pampa basins about 50 m from the river. Initial study trips were utilized to know more about the plants of ethnobotanic importance, Rare and Endangered plants especially of medicinal importance.Herbarium and photographs were made.Tribal people were consulted to get information on the utility of plants, detailed methods of uses. Authentic identifications were done with the help of BSI Coimbatore, KFRI Trichur, Kerala Medicinal Plant Board, Govt. of Kerala, Pankaja Kasthuri Medical College, Thiruvananthapuram and Ousshadhi, Govt. of Kerala, Thrissur, Kerala. These institutions were visited to compare the specimens with the Herbaria preserved there and also to obtain expert opinion. Strategies for in-situ and ex-situ conservation were undertaken by planting them in the Botanical Garden of the St. Thomas College and developed a suitable protocol for tissue culture method.

Tylophora asthmatica of Asclepaidaceae is taken as the experimental plant which is traditionally used as a folk remedy for the treatment of bronchial asthma, bronchitis, inflammation, allergies, rheumatism, and dermatitis etc. The tissue culture work undertaken was to study the effect of different phytohormones such as IAA, IBA, NAA, 2, 4-D, BA and KIN. Nodal segments stem and leaves were used as the source of explants for the study. They showed different response in different hormonal concentrations and combinations.

RESULTS

From study it is observed that there are 73 plants Rare, Endangered and Threatened (RET) and 11 are endangered medicinal plants in the Pampa basin. Observations suggest that a good number of medicinally important plants are on the verge of extinction. Strategies for in-situ and ex-situ conservation were undertaken by planting them in the Botanical Garden of the St. Thomas College and developed a suitable protocol for tissue culture method. Tribal people are consulted to get information in which ways they utilize these plants in their life style. Visit in tribal hamlets helped to witness their pattern of plant utilizations.

Rare, Endangered and Threatened (RET) plants Identified from Pampa basin

Name of the Species	Family
Amomum pterocarpum Thw.	*Zingiberaceae*
Ampelocissus indica (L.) Planch.	*Vitaceae*
Andrographis explicata (Clarke) Gamble	*Acanthaceae*
Anisochilus argenteus Gamble	*Lamiaceae*
Begonia subpeltata Wight	*Begoniaceae*
Biophytum insigne Gamble	*Oxalidaceae*
Buchanania lanceolata Wight	*Anacardiaceae*
Carex wightiana Nees in Wight	*Cyperaceae*
Cayratia pedata (Lam.) A. Juss. ex Gagnep. var. glabra Gamble	*Vitaceae*
Ceropegia beddomei Hook. f.	*Asclepiadaceae*
Cinnamomum riparium Gamble	*Lauraceae*
Cinnamomum travancoricum Gamble	*Lauraceae*
Clematis bourdillonii Dunn	*Ranunculaceae*
Colubrina travancorica Bedd.	*Rhamnaceae*
Commelina indehiscens Barnes	*Commelinaceae*
Commelina wightii Rao	*Commelinaceae*
Curcuma decipiens Dalz.	*Zingiberaceae*
Dalbergia beddomei Thoth.	*Fabaceae*
Dalbergia latifolia Roxb.	*Fabaceae*
Diospyros barberi Ramas.	*Ebenaceae*
Ehretia wightiana Wall. ex G. Don	*Boraginaceae*
Elaeocarpus venustus Bedd.	*Elaeocarpaceae*
Embelia gardneriana Wight	*Myrsinaceae*
Garcinia travancorica Bedd.	*Clusiaceae*
Glochidion bourdillonii Gamble	*Euphorbiaceae*
Glycosmis macrocarpa Wight	*Rutaceae*
Hedyotis beddomei Hook. f.	*Rubiaceae*
Impatiens wightiana Bedd.	*Balsaminaceae*
Ixora monticola Gamble	*Rubiaceae*
Memecylon sisparense Gamble	*Melastmaceae*

Phyllanthus beddomei (Gamble) Mohanan	*Euphorbiaceae*
Piper hapnium Buch.-Ham. ex Hook. f.	*Piperaceae*
Pittosporum dasycaulon Miq	*Pittosporaceae*
Pothos armatus Fischer	*Araceae*
Psychotria barberi Gamble	*Rubiaceae*
Trichosanthes anamalaiensis Bedd.	*Cucurbitaceae*
Vateria macrocarpa Gupta	*Dipterocarpaceae*
Vernonia beddomei Hook. f.	*Asteraceae*
Acorus calamus L.	*Araceae*
Ampelocissus araneosa (Dalz. & Gibson) Lawson	*Vitaceae*
Artocarpus hirsutus Lam.	*Moraceae*
Baliospermum montanum (Willd.) Mull. Arg.	*Euphorbiaceae*
Calophyllum apetalum Willd.	*Clusiaceae*
Cinnamomum macrocarpum Hook. f.	*Lauraceae*
Coscinium fenestratum (Gaertn.) Coleb.	*Menispermaceae*
Cycas circinalis L.	*Cycadaceae*
Diospyros paniculata Dalz.	*Ebenaceae*
Drosera indica L.	*Droseraceae*
Embelia ribes Burm. f.	*Myrsinaceae*
Garcinia gummi-gutta (L.) Robson	*Clusiaceae*
Gardenia gummifera L.f.	*Rubiaceae*
Gloriosa superba L.	*Colchicaceae*
Hedychium coronarium Koenig	*Zingiberaceae*
Holostemma ada-kodien Schult.	*Asclepiadaceae*
Hydnocarpus pentandra (Buch. -Ham.) Oken	*Flacourtiaceae*
Madhuca neriifolia (Moon) H. J. Lam	*Sapotaceae*
Michelia champaca L.	*Magnoliaceae*
Terminalia arjuna (Roxb. ex DC.) Wight & Arn.	*Combretaceae*
Tinospora sinensis (Lour.) Merr.	*Menispermaceae*
Tragia bicolor Miq.	*Euphorbiaceae*
Vateria indica L.	*Dipterocarpaceae*
Adhatoda beddomei C. B. Clarke	*Acanthaceae*
Cinnamomum beddomei Gamble	*Lauraceae*

Hopea parviflora Bedd.	*Dipterocarpaceae*
Woodfordia fruticosa (L). Kurz.	*Lythraceae*
Hydnocarpus pentandra (Buch. -Ham.) Oken	*Flacourtiaceae*
Madhuca neriifolia (Moon) H. J. Lam	*Sapotaceae*
Michelia champaca L.	*Magnoliaceae*
Terminalia arjuna (Roxb. ex DC.) Wight & Arn.	*Combretaceae*
Tinospora sinensis (Lour.) Merr.	*Menispermaceae*
Tragia bicolor Miq.	*Euphorbiaceae*
Vateria indica L.	*Dipterocarpaceae*
Adhatoda beddomei C. B. Clarke	*Acanthaceae*
Cinnamomum beddomei Gamble	*Lauraceae*
Hopea parviflora Bedd.	*Dipterocarpaceae*
Woodfordia fruticosa (L). Kurz.	*Lythraceae*
Cissampelos pareira Linn.	*Menispermaceae*

2. Red listed Medicinal plants identified

Acorus calamus L.	*Araceae*
Adenia hondala (Gaertn.) de Wilde	*Passifloraceae*
Aegle marmelos (L.) Correa	*Rutaceae*
Baliospermum montanum (Willd.) Muell.	*Euphorbiaceae*
Saraca asoca (Roxb.) de Wilde	*Caesalpiniaceae*
Terminalia cuneata Roth	*Combretaceae*
Rauvolfia serpentina (L.) Benth. ex	*Apocynaceae*
Gloriosa superba L.	*Liliaceae*
Embelia ribes Burm. f.	*Myrsinaceae*
Holostemma ada-kodien Schult. in Roem. & Schult.	*Asclepaidaceae*
Typhlora asthmatica	*Asclepaidaceae*

DISSCUSSION

An environment committee of the Kerala assembly, which recently came out with a report on Sabarimala, said the hill shrine faces a grave environmental risk mainly because of the degradation of the Pampa river system. "The menace posed by pollutants and the stress caused on its fragile environs is a grave threat to the very sanctity of the forest temple at Sabarimala," the report warned. Another study

conducted by the Thiruvananthapuram-based government-funded Centre for Earth Science Studies said the Pampa, the third largest river in Kerala fed by nearly 270 mountain streams, has "reached horrifying levels of pollution and degradation".

The Pampa Parirakshana Samithi (PPS), an ecogroup that has been campaigning for the cause of river pampa since the past 25 years, has predicted chances of a major deluge in Pathanamthitta Dist., if the authorities concerned failed to rejuvenate the tributaries of river pampa in a time bound manner(Sukumaran Nair, 2015). Indiscriminate sand mining has lowered the Pampa river-bed resulting in salinity intrusion up to its Aranmula-Kozhenchery stretch in the recent past. River banks are illeagally converted in to waste dumbing areas over the past two decades.

In India, the floristic diversity study and conservation strategies have been advanced much. Several in situ and ex situ conservation measures have been taken through biosphere reserves, national parks, botanical gardens, greenhouses, etc (Singh & Singh, 2002). In spite of all those efforts, plant species are disappearing due to various causes and the red list becoming longer (Muthu & Ganasan, 2012). Out of the 260 species of the RET plants identified by Anilkumar *et al.*, 2006 in Pathanamthitta Dt., 73 are found in the Pampa basin, indicating a wide range of biodiversity. Through various tissue culture and micropropagation techniques vanishing plants can be regenerated. Also, a database regarding species which are recovering from RET to normal status, is essential to update the floristic status of the country. Declaration of river Pampa as a biodiversity heritage site and development of four to five metre wide ecotone on either river banks, environmental education and awareness campaign are certain urgent steps should be taken. Conservation projects with the help of neighbouring Colleges, Schools and NGOs should be ensured. The Ministry of Environment and Forests should take further steps to bann collection of more endangered species of medicinal plants from their natural habitats (Binu, 2010).

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International Journal on Environmental Sciences **6** (2) : 265-268, July-December 2015 **Research Article**
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A Study on Physical Characteristics of Fresh Rumen Content and Yield with Relation to Different Age Groups of Goat

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ABSTRACT

A study has been carried out to see the effect of age of goat on the yield and physical characteristics of goat rumen content. Three numbers of treatment groups were created i.e. T1 (6 months-8 months old goats), T2 (9 months-12 months old) and T3 (15-18 months old). In each treatment group data's pertaining to body weight of goats, yield of fresh rumen content, pH and temperature were recorded. The live weight of the animals was taken and then they were slaughtered. After this the rumen contents were filled in LDPE plastic bags and weighed with the help of hanging weighing balance. Then the rumen contents were brought to the laboratory for recording pH and temperature. There was no difference found in the temperature and pH value in between the treatment groups. The yield of rumen content showed a positive correlation with the body weight. Here it was observed that with the increase in age of goats the body weight found to be increased and after it reached its peak again it showed a decreasing trend in T3 group and the same was found in weight of rumen content.

Keywords: Goat rumen content, Yield, pH, Temperature.

INTRODUCTION

In the present situation our country stands first in livestock population and stands second in goat population. Most of the people in India prefer goat meat, so more numbers of goats are slaughtered for which more amount of by-products produced such as rumen content, which is regarded as simple waste material and it is dumped or thrown as such. It creates bad odour, adds pollution to the environment and also contaminate the fresh lot of meat. As per the previous researchers, goat rumen content contain lots of vitamin-B, Probiotic organisms and acts as additive (Adenji, 2008) and also enriched with 10 to 20 % crude protein (Hakan et al., 2013).Use of rumen content in livestock feed will reduce the feed cost and also alleviate the pollution problem (Mohammed et al.,2008). Feed cost stands as main hurdle in the way of

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progress of the livestock industries which indirectly affect the economic condition of the country. In this regard the yield of rumen content and its physical characteristics assessment is most important where the rumen content will be used as feed material for different animal species with a objective to reduce the cost of feed while maintaining the protein requirement.

MATERIALS AND METHODS

A study has been carried out to see the effect of age on the yield and physical characteristics of goat rumen content. Three numbers of treatment groups were formed i.e. T1(6 months-8 months old goats), T2 (9 months-12 months old) and T3 (15-18 months old). In each treatment group data's pertaining to body weight of goats, yield of rumen content, pH and temperature were recorded. The live weights of the animals were taken and then they were slaughtered. After this the rumen contents were filled in LDPE plastic bags and weighed with the help of hanging weighing balance. Then the rumen contents were brought to the laboratory where the pH and temperature were recorded with the pH meter and thermometer respectively.

RESULTS AND DISCUSSION

Effects of age groups on the yield of rumen content and its physical characteristics were assessed. The values of pH and temperature observed are given in Table I and figure II. In some samples of rumen content the lower value of pH observed such as 5.5 to 5.8 might be due to the different feeding habit of goats which may be reared on pasture or on stall fed and the physical form of the diet, e.g. a lessening in the forage particle size or the processing of grain, decreases ruminal pH (Krause et al. 2002). A lower ruminal pH observed could be correlated with elevated microbial nitrogen surge from the rumen, high volatile fatty acid concentrations, milk and milk component yields and dry matter intake, but lower concentrations of fat and protein in milk (Kolver and de Veth , 2002). Feeding of more amount of grain before slaughter or the amount of rumen fermentable carbohydrate present in the rumen could be one of the reason for the lower pH value (Yang et al. 2001; Krause et al. 2002). There was no difference found in the temperature value in between the treatment groups. In some samples the lower value of temperature observed could be due to difference in timing of collection, sampling methods and sampling areas and also the environment of the rumen content. The yield of rumen content showed a positive correlation with the body weight of goats mostly yield of rumen content observed was 4 to 5 % of the body weight which is more than the findings of McGregor B.A. (2000) who reported as 2.2% of the live weight. This variation found in yield of rumen content

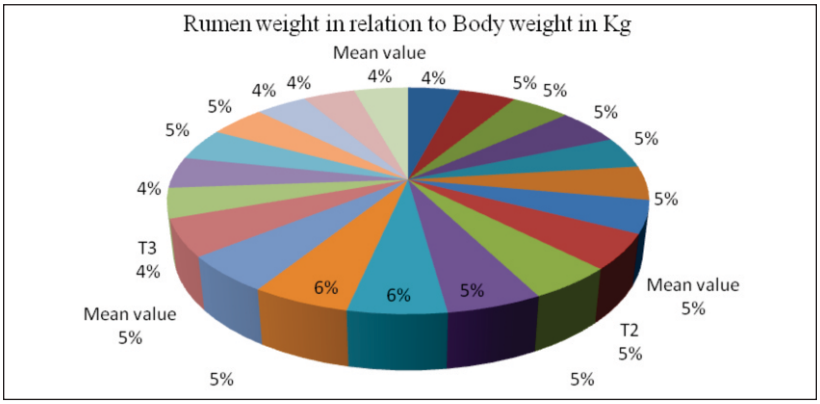

Fig. 1: Relation between the rumen content weight with respect to the body weight of goats.

Table 1: Mean values of effect of age group on pH, Temperature and weight of rumen content.

	Body weight in Kg	Weight of rumen content in kg	pH of rumen content	Temperature in degree centigrade
T1 (6-8 months old)	12	0.60	5.5	38.0
	13	0.71	6.4	39.0
	13.5	0.60	5.9	37.8
	14.6	0.73	6.6	39.0
	12.9	0.61	6.2	38.3
	13.8	0.53	6.3	37.8
Mean value	13.3	0.63	6.15	38.31
T2 (9-12 months old)	14.4	0.72	5.8	35.8
	13.9	0.66	6.5	39.1
	15.5	0.75	6.6	38.6
	16.0	0.80	6.7	38.1
	15.9	0.68	5.9	37.8
	15.2	0.77	6.2	37.7
Mean value	15.15	0.73	6.28	37.85
T3 (15-18 months old)	12.2	0.61	5.5	38.0
	12.8	0.57	6.8	37.6
	13.1	0.62	6.5	38.3
	12.9	0.65	5.9	38.4
	11.8	0.49	6.7	36.9
	11.9	0.46	6.0	35.8
Mean value	12.45	0.56	6.23	37.5

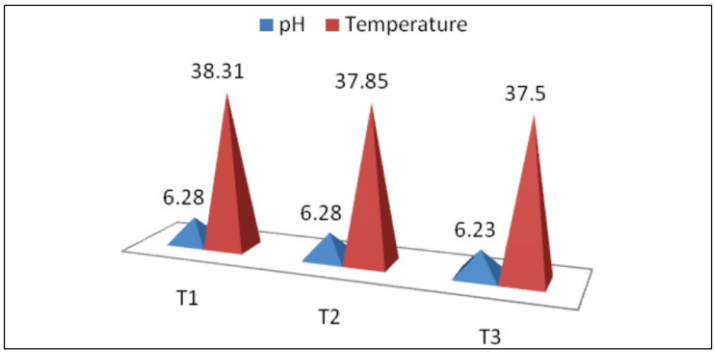

Fig. 2: Effect of age group on pH and temperature of rumen content.

with respect to the body weight might be due to differences in gut fill and fleece weight and individual variation between animals McGregor B.A. (2000). The mean body weight of T1 was found to be 13.3 kg, while for T2 it was 15.5 and for T3 it was 12.45 represented in table I and figure I. Here it was observed that with the increase in age of goats the body weight found to be increased and after it reached its peak again it showed a decreasing trend in T3 group and the same was found in weight of rumen content.

CONCLUSIONS

From the estimation of pH the dominance of type of bacterial species can be assessed and from the yield of rumen content it can be quantified that how much amount of rumen content is to be incorporated in feed for proper disposal of the same for decreasing the pollution. The health status of animal can be known from the rumen temperature.

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International Journal on Environmental Sciences **6** (2) : 269-272, July-December 2015 **Research Article**
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Enhancement of Yield and Income of Farmers through Demonstration of Freshwater Prawn Farming with Carps within a Pond Environment

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ABSTRACT

The study was carried out from 02/11/12 to 03/05/13 with an objective for enhancement of yield and income of farmers through demonstration of Freshwater Prawn farming with Carps. During this experiment total five no. of farmers each having two no. of pond of Angul district, Odisha were selected and randomly divided into two groups i.e. treatment in one pond as Farmers Practice (FP) and treatment in another pond as Recommended Practice (RP) for six months. In farmers practice they usually stocked mixed seeds (20-40) mm size of Indian Major Carps at the rate of 15000 no./ha. without adding freshwater prawn into the culture system. In recommended practice the farmers were provided technical knowledge regarding freshwater prawn farming in polyculture system/composite pisciculture system through training and demonstration. For increasing the yield various management measures were taken i.e. water exchange, aeration, harvesting of bigger size prawn from fourth month onwards etc. Culture of fresh water prawn species along with carps resulting in increase of overall yield i.e. [15(Fish) +4 (Prawn) q/ha] against farmer's practice [14.0 (Fish) q/ha] during the experiment. Similarly Net profit of Rs. 95,000 was recorded from this technology with benefit: cost (B: C) ratio of 1.54 against Rs. 35,000 and 1.30 respectively from farmer's practice. Therefore, it is recommended to culture freshwater prawn species in polyculture system considering its fast growth rate, immense potential for large scale adoption by the farmers/entrepreneurs, economical viability and higher profit realization from unit area. Harvesting was done during inter-moult period with complete draining the pond followed by hand picking. Then the data like fish and prawn yield (Quintal/hectar), average net return and B: C was recorded and analysed using statistical tools like Average mean value and percentage.

Keywords: Freshwater prawn, Carp, Pond environment, Yield.

INTRODUCTION

In recent years freshwater prawn species has received due attention of the farmers due to higher economic return from unit area. Further the increasing demand of the species in

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international market provides the scope for expansion of cultivation of this species. The species comes under the genus Macrobrachium are commercially important. Among the Macrobrachium species *M. rosenbergii* (golda) is very much attractive in world market for its nutritional value and taste. Golda is a freshwater species (0-5 ppt) and during spawning time they need saline water (salinity 5 to 20 ppt).The Indian river prawn, *M. malcolmsonii* is another freshwater prawn species, possesses potential for its culture. These species have a number of advantages which make them as an excellent species for polyculture i.e. adaptability to wide range of temperature (20 0C-32 0C), fast growing capacity that helps in reaching marketable size within 4-6 months, high nutritional value, omnivorous feeding habits etc. The freshwater prawn culture in Angul district of Odisha is still at its infancy. This study was an attempt to demonstrate the freshwater prawn farming with carps for enhancement of yield and income of the respective farmers of this district.

MATERIALS AND METHODS

The study was carried out from 02/11/12 to 03/05/13 with an objective for enhancement of yield and income of farmers through demonstration of Freshwater Prawn farming with Carps. During this experiment total five no. of farmers each having two no. of pond of Angul district, Odisha were selected and randomly divided into two groups i.e. treatment in one pond as Farmers Practice (FP) and treatment in another pond as Recommended Practice (RP).The experiment was carried out for a period of six months. In farmers practice they usually stocked mixed seeds (20-40) mm size of Indian Major Carps at the rate of 15000 no./ha. without adding freshwater prawn into the culture system. In recommended practice the farmers were provided technical knowledge regarding freshwater prawn farming in polyculture system/composite pisciculture system through training and demonstration. The farmers were advised to stock 5000 no. of carp fingerlings along with 7500 no. of freshwater prawn juveniles / ha. area of fish pond. After stocking, the farmers used cow dung, TSP, urea to increase the natural fish food organisms and used supplementary feed @ 10% of the biomass during the initial month, followed by 3% of the biomass in subsequent rearing period to provide the nutrition. Constant water depth of 1.5-2.0 m was maintained throughout the study period. Water quality was monitored at every 15 days interval and appropriate intermittent liming and fertilization measures were taken. Transparency of 30-40 cm was maintained through regular use of fertilizers to avoid the growth of bottom algae. For increasing the yield additional management measures were also taken i.e. water exchange, aeration, harvesting of bigger size prawn from fourth month onwards etc. Harvesting was done during inter-moult period with complete draining the pond followed by hand picking. Then the data like fish and prawn yield (Quintal/hectar), average net return and B: C was recorded and analysed using statistical tools like Average mean value and percentage.

RESULTS AND DISCUSSION

Culture of fresh water prawn species along with carps resulting in increase of overall yield i.e. [15(Fish) +4(Prawn) q/ha] against farmer's practice [14.0 (Fish) q/ha] during the experiment Table-1. Similarly Net profit of Rs. 95,000 was recorded from this technology with benefit: cost (B: C) ratio of 1.54 against Rs. 35,000 and 1.30 respectively from farmer's practice Table-2. Prawns attain around 50 g during this period. The increase in overall yield of the polyculture system could be due to the fast growth of Freshwater prawn owing to its compatibility with carp and total food utilization of the pond environment (Durairaj *et al.*, 1992 and Peebles, 1978). Proper stocking density and size is one of the major causes for more yield of the polyculture system which is supported by

(Kannupandi, 1995 and Rama Rao *et al*, 1992). The enhanced yield as compared to carp monoculture is may be due to increase in survivability rate due to less chance of crowding and cannibalism after maintaining the appropriate stocking size and density, more metabolic growth rate and regular health management etc. (Sampathkumar, 2000). This finding is also agreeable with some researchers (Huq *et al.*, 2004 and Shah and Khan., 2003).

Table 1: Abstract of fish and prawn yield (F=Fish and P=Prawn).

Sl. No.	Pond area (ha)	Production from check pond (qtl.)	Yield of check pond (q/ha)	Production from Demonstrated pond (qtl.)	Yield of Demonstrated pond (q/ha)
1	0.2	2.8(F)	14(F)	2.4(F)+1.2(P)	12(F)+6(P)
2	0.3	3.6(F)	12(F)	4.5(F)+1.2(P)	15(F)+4(P)
3	0.6	9.6(F)	16(F)	10.2(F)+1.8(P)	17(F)+3(P)
4	0.4	5.2(F)	13(F)	6.0(F)+2.0(P)	15(F)+5(P)
5	0.5	7.5(F)	15(F)	8.0(F)+1.0(P)	16(F)+2(P)
		Avg.=14(F)			Avg.=15(F)+4(P)

Table 2: Abstract of economic parameters.

Sl. No.	Economic parameters	Farmers' practice (FP)	Recommended practice (RP)
1	Average cost of cultivation (Rs./ha)	1,15,000	1,75,000
2	Average gross return (Rs./ha)	1,50,000	2,70,000
3	Average net return (Rs./ha)	35,000	95,000
4	Benefit cost ratio (B:C)	1.30	1.54

CONCLUSIONS

From the demonstration it is concluded that inclusion of freshwater prawn species along with carps is essential to make the system economically more viable. Further, the international market being the major outlet for the commodity, an enhancement in the production in the country may not affect the farm gate price of the produce. The domestic market for the product is also increasing at a faster rate due to the increasing purchasing power of the people. Therefore, it is recommended to culture freshwater prawn species in polyculture system considering its fast growth rate, immense potential for large scale adoption by the farmers/entrepreneurs and higher profit realization from unit area.

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International Journal on Environmental Sciences **6** (2) : 273-280, July-December 2015 **Research Article**
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Physiochemical and Biological Analysis of Wastewater Effluents from Dairy Industries located in Delhi-NCR

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ABSTRACT

People on globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, use of fertilizers and man-made activity water is highly polluted with different harmful contaminants. It is necessary to know details about different physico-chemical parameters such as color, temperature, acidity, hardness, pH, sulphate, chloride, DO, BOD, COD, alkalinity used for testing of water quality. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life.

Effluent samples from dairy industries located in Delhi-NCR were investigated for physiochemical properties and microbial loads. Analysis on the samples of wastewater was performed to determine the physical, chemical and biological pollution. The parameters considered in the present study include Temperature, pH, TDS, TSS, BOD, COD, Chloride, and Sulphate. The pollution levels from these industries were found to be very high and hence proper care must be taken for the treatment of such effluents before they are released to the water bodies. Many big industries have their own effluent treatment plants, but small scale industries are not following the guidelines prescribed for the treatment of industrial effluents. The study has shown that almost all the parameters are on the higher levels than the prescribed limit and hence proper treatment methods are needed.

Keywords: Physiochemical analysis, dairy waste water, waste water effluent, microbial loads, pollution.

INTRODUCTION

Industrialization is backbone for development of country. But pollution caused by industry is a serious concern in throughout the world.[1] Of all industrial activities, the food sector has one of the highest consumptions of water and is one of the biggest producers of effluent per unit of production. The dairy industry is an example of this sector. Dairy industry is one of the major food industries in India, and India ranks in top among the maximum major milk producing nation.[2] The dairy industry is one of a major source of waste water.

Waste water is generated in milk processing unit, mostly in pasteurization, homogenization of fluid milk and the production of dairy products such as butter, cheese, milk powder etc. Most of the milk processing unit use “clean in place” (CIP) system which pumps cleaning solutions through all equipment in this order water rinse;

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caustic solution (sodium hydroxide) wash, acid solution (phosphoric or Nitric acid) wash, and sodium hypo-chlorite disinfectant.[3] These chemicals eventually become a part of waste water. Large amount of water is used to clean dairy processing plants; hence, the resulting waste water can contain detergent, sanitizers, base, salts and organic matter, depending upon source. Waste water volume and strength fluctuated widely from day to day due to partly differences in production, therefore, data of effluent or waste water volume per unit of product processed (liters waste water/kg product), waste water concentration (mg/L) and weight of waste generated per unit of product processed have significant variation.[4] Climate of the area and production of the dairy plant are two major reasons, responsible for changing waste water character. This variation is not only from one industry to another dairy industry but also from season to season and even day to day.

Milk has important place in human life. The dairy industry involves processing of raw milk into products like consumer milk, butter, cheese etc. The quantity of water required in a milk processing plant depends upon the size of the plant, generally expressed in terms of the maximum weight of milk handled in a single day, and the processes involved. The daily volume of water required may vary widely, depending mainly on the availability of water and the control of all water using operation in the plant. The operations where the process involves continuous flow, the amount of water needed for rinsing and washing is not necessarily proportional to the amount of product processed. Most of the waste water discharged into water bodies, disturbs the ecological balance and deteriorates the water quality. The casein precipitation from waste water decomposes further into highly odorous black sludge. Effluent from milk processing unit contains soluble organics, suspended solids, trace organics which releases gases, causes taste and odor, impart color and turbidity, and promote eutrophication.

Dairy industry produces huge volumes of liquid waste. This waste poses escalating disposal and pollution (High BOD & COD) problems and represents a loss of valuable biomass and nutrients. Dairy plants are found all over the world, but because their sizes and the types of manufactured products vary tremendously, it is hard to give general characteristics. The dairy industry can be divided into several production sectors. Each division produces wastewater of a characteristic composition, depending on the kind of product that is produced such as milk, cheese, butter and milk-powder. Hardly any solid waste is produced by the dairy industry. The main solid waste produced by the dairy industry is the sludge resulting from wastewater purification.

Wastewater from dairy industry may originate from the various sources. Wastewater results from tank, truck, storage tank washing, pipe line washing and sanitizing. It contains milk solids, detergents, sanitizers and milk wastes. Wastewater is mainly produced during cleaning operations. Especially when different types of product are produced in a specific production unit, clean-up operations between product changes are necessary. In developing countries, the main problem is pollution through spoilage of milk. Waste results mainly from the production of whey, wash water, curd particles etc. The amount of fine particles in the wash water increases if mechanical washing processes are used. Butter washing steps produce wash water containing buttermilk. Skim milk and buttermilk can be used to produce skim milk powder in the factory itself or these materials may be shipped to another dairy or food plant. In case of the production of milk powder, environmental problems are caused by high energy consumption, by cleaning and by emission of fine dust during the drying process. Problems related to the production of condensate and khoa are mainly caused by the high energy consumption during the evaporation process. The main suspended solids are coagulated milk and fine particles of cheese curd.

In land received waste water affect the soil quality and soil structure and part of waste water can also leach is to underlying groundwater and affect its quality.[5] The problem is more serious, when it concerns waste water discharge before treatment from dairy or milk processing industry. A typical Indian dairy factory generates large amount of waste water daily with considerable concentration of organic matter (fat, protein and carbohydrates) and nutrients (Nitrogen and phosphorous) originating from the milk and the milk products. Disposal of untreated water is rapidly becoming a major economic and societal problem faced by the dairy processing industry in many aspects. Almost all the dairy factories are facing the problem of water treatment, disposal and utilization of the waste water. Disposal of waste water into rivers, land, fields and other aquatic bodies, without or with partial treatment, in crude tanks, will soon offer a serious problem to health and hygiene.

There are so many investigations underway to finding solution for cheaper treatment, easy disposal and utilization of waste water from milk processing unit, in India as well as in abroad.

MATERIALS AND METHODS

For the present study, Analysis was performed by using standard protocols by APHA, 2005. The Physical parameter-Temperature, pH, TS, TDS and SS and Chemical parameters-Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Sulphate, Chloride, Oil and Grease were analyzed.

Sample Collection and Preparation

In this study, wastewater effluent samples were collected from Dairy industries, located in Delhi-NCR. Biological and Physiochemical assessments were carried via microbial analysis and standard APHA protocols. Sterile containers were used to collect samples from the industry. Samples were transported immediately to the laboratory for analysis.

Physiochemical Analysis

The pH of samples was determined in the laboratory using pH Meter (Systronics Digital pH Meter 335) and temperature in Degree Celsius on scientific thermometer. TS, TDS and SS were estimated by gravimetric method.

Chloride tested as a known volume of filtered sample (50ml) is taken in a conical flask, to which about 0.5ml of potassium chromate indicator is added and titrated against standard silver nitrate till silver dichromate ($AgCrO_4$) starts precipitating.

BOD analysed as 1000ml of distilled water, 1ml each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride solution is added. Take about 5ml of the sample and dilute it to 300ml with dilution water prepared. The diluted sample is taken in two bottles. The dissolved oxygen in one bottle is determined immediately and in the bottle after five days of incubation at 20°C.

COD was calculated as 15ml of conc. sulphuric acid with 0.3g of mercuric sulphate and a pinch of silver sulphate along with 5ml of 0.025M potassium dichromate is taken into a Nessler's tube. 10ml of sample (thoroughly shaken) is pipetted out into this mixture and kept for about 90 minutes on the hot plate for digestion. 40ml of distilled water is added to the cooled mixture (to make up to 50ml) and titrated against 0.25M FAS using ferroin indicator, till the colour turns from blue green to wine red indicating the end point.

Oil and Grease calculated as 50 mL of effluent was taken in fat extraction flask. Add 50 mL petroleum ether (40-60 ^{0}C). Mixed and allowed to stand for 10 min. Decanted off the ethereal layer in clean dry previously weighed aluminium fat dish. 5 mL of ethanol was added to the flask. Mixed and allowed to stand for 5 min. Decanted off the top layer into the dish, extract was dried on hot plate, cooled in a desiccator and weight was taken.

Microbial Analysis

Serial dilutions (10-1 to 10-10) were carried out on sample and were cultured using the spread plate method. Nutrient Agar was inoculated with 10-3 and more dilution of the sample for isolating resistant bacteria present and surviving in the waste water sample. The NA plates were incubated at 37°C for 24 hour. For each plate cultured, observation was made on at least one plate of the series whose bacteria numbers were sufficiently low which allowed the development of well separated colonies. The colonies were sub-cultured until pure cultures of the isolates were obtained. These were then stocked for further biochemical analysis.

RESULTS

This study was undertaken to detection of the important pollution parameters in dairy industry wastewater.

Physico-chemical Parameters

Certain physiochemical parameters were studied in laboratory for the waste water sample collected from dairy industry and the results shows that they are at the high level. The

Table 1: Physiochemical parameters from dairy effluent

Parameters	Calculated Value (mg/L)
Temperature	360C
pH	9.2
DO (mg/l)	1.2
BOD (mg/l)	790
COD (mg/L)	1495
TDS (mg/L)	1560
SS (mg/L)	252
TS (mg/L)	1690
Sulphate (mg/L)	223
Chloride (mg/L)	146
Oil & Grease (mg/L)	3

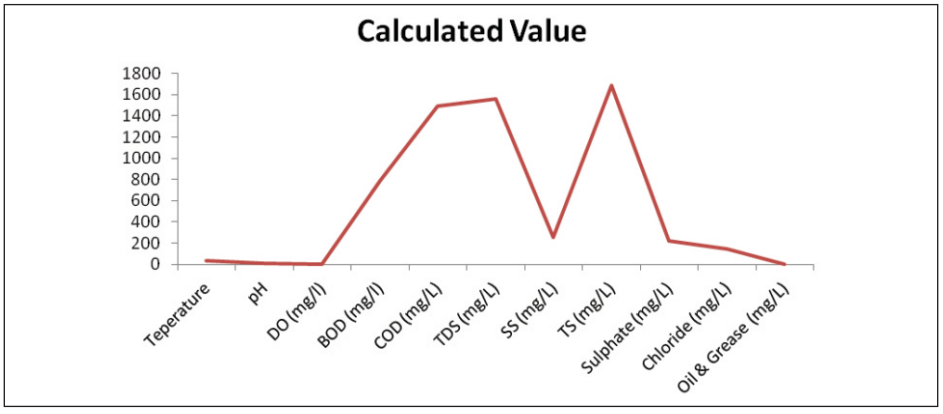

Fig. 1: Graphical representation of physiochemical parameters.

parameters studied from untreated waste water sample were on the higher and alarming level. (Table 1 and Figure 1)

Bacterial Isolates

Serial dilution of the sample was done and different dilutions were spread on Nutrient Agar plates for isolating pure colonies of bacteria. Total 7 Strains (IS-1 to IS-7) of bacteria were isolated from sample. Gram staining and microscopic observation was performed for the isolated strains to know their morphological characteristics. Result shows that, most of the strains obtained were Gram positive.

Table 2: Results of Gram staining and shape of isolated strains.

Isolate	Gram Staining	Shape
IS-1	Gram Negative	Rods
IS-2	Gram Positive	Cocci
IS-3	Gram Positive	Rods
IS-4	Gram Positive	Rods
IS-5	Gram Positive	Cocci
IS-6	Gram Negative	Rods
IS-7	Gram Negative	Cocci

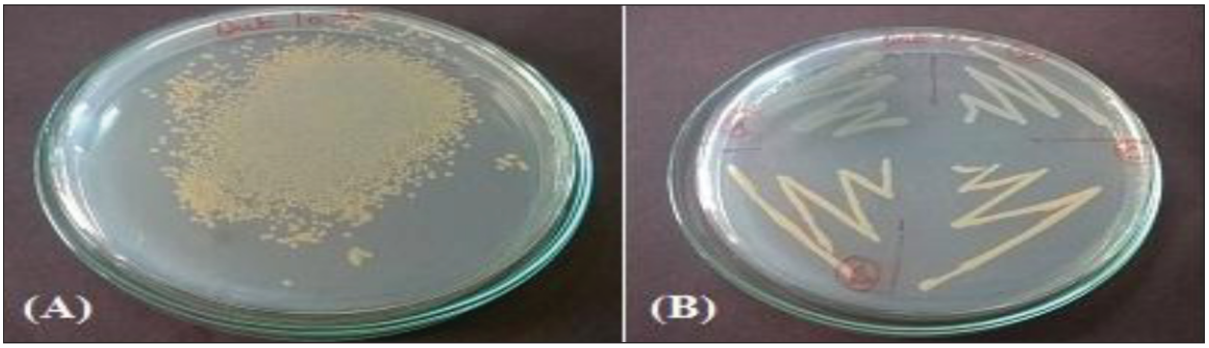

Fig. 2: (A) Nutrient Agar spread plate of sample dilution, (B) Streak Plate for Single colony isolation in order to obtain pure culture.

Microscopic observation of isolated strains gave their shape and most common was Rod Shape. (Figure 2 and Table 2)

Biochemical Characteristics

The isolated strains were studied for their biochemical characteristics. The test for biochemical characteristics included carbohydrate degradation, nitrate reduction, gelatin hydrolysis and hydrogen sulphide test. Results of the biochemical characteristics are shown in the Table 3.

Gelatin Hydrolysis

It can be seen from Figure 3 with the help of

Table 3: Results of biochemical characteristics .

Characteristics	IS-1	IS-2	IS-3	IS-4	IS-5	IS-6	IS-7
Glucose Degradation	+	+	+	+	+	+	+
Sucrose Degradation	+	+	+	+	+	+	+
Maltose Degradation	-	-	-	-	+	-	-
Gelatin Hydrolysis	+	+	+	+	-	-	-
Hydrogen Sulphide Production	+	+	-	-	+	+	+

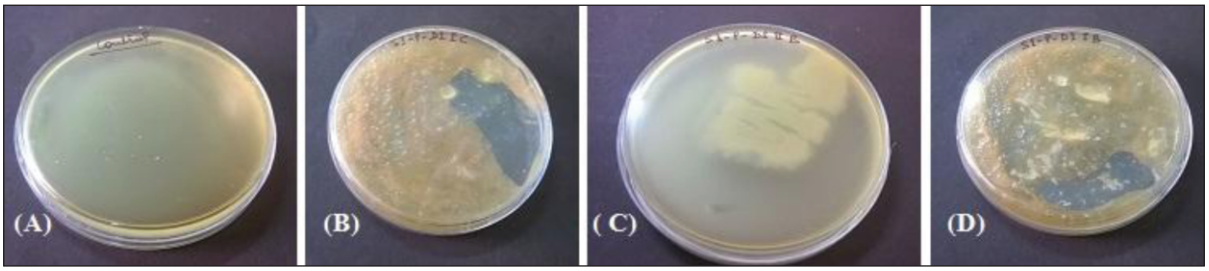

Fig. 3: (A) Gelatin Agar Media Control Plate, (B)&(D) Bacterial activity showing positive result, (C) No bacterial activity showing negative result.

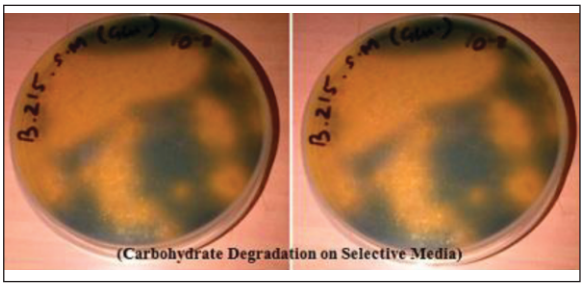

Fig. 4: Plates showing carbohydrate degradation on selective media, indicating blue color plate turning yellow.

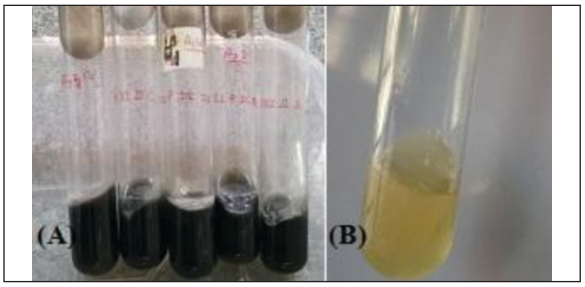

Fig. 5: (A) Test tubes indicating black color showing positive result, (B) Control tube for the experiment

investigate the main pollution parameters of wastewater in dairy industry. The wastewater samples were tested for BOD (Biological oxygen demand), COD (Chemical oxygen demand), DO (Dissolved oxygen), Chloride, Oil and Grease, TSS, Sulphate and pH values. The results indicate that pollution parameter levels for untreated wastewater effluent samples of dairy industry were found high and alarming. To avoid the environmental pollution and to protect public health, wastewater treatment systems are recommended for dairy industry. It has been determined as the conclusion that the BOD, COD, TSS, Oil and Grease values in the wastewater of the milk industry prior to treatment are high. It has also been observed that the values of parameters determined in the wastewater samples after the treatment have been reduced to comply with the legal limits set by Central Pollution Control Board, India. Based on these findings, we have come to the conclusion that the effluent treatment of the

milk industry is inevitable for the prevention of the increase of the pollution loads, for the protection of the environmental health and the preservation of the ecological balance.

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International Journal on Environmental Sciences **6** (2) : 281-286, July-December 2015 **Research Article**
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Effect of Environment on Corrosion Behaviour of Aluminium

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ABSTRACT

Corrosion is the deterioration of metals by chemical interaction with their environment. Aluminium finds extensive industrial and household applications where it gets exposed to variety of aggressive and corrosive environments. The chemical attack at the Al surface breakdowns the protective oxide layer and subsequently leads to a sequence of electrochemical reactions causing its corrosion. The present study investigated the corrosion behavior of Al in saline environment (0.5M NaCl) using electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization measurements. The Nyquist and Bode plots show the decreased polarization resistance and impedance with immersion time. Tafel plots indicate the high corrosion rate (mm/yr) 1.13 at scan rate 0.001V/s. Scanning electron microscopy (SEM) reveals the characteristic pitting corrosion in Al under saline environment.

Keywords: Corrosion Behaviour, Aluminium.

INTRODUCTION

The destructive loss of a metal by reaction with the environment is termed as corrosion which imposes great damage to domestic appliances and industrial equipments[1]. Localized microclimate of marine, industrial, urban and rural areas constitutes the corrosive environment for the metal. The severity of corrosion increases as a function of contaminant levels present in the environment which serves as electrolytes to facilitate the corrosion process[2-5]. The electrolyte can range from fresh water, salt water, rain or even moisture to the strongest alkali or the strongest acid solution, including, but not limited to, wastewater, chemicals and sewage in combination with other factors such as wind, humidity, fog and temperature. The chemical attack by these contaminants results in the premature failure of metals through oxidation-reduction reactions. Laundry facilities, pool cleaners, household cleaning agents which are typically sodium or chloride-based compounds are the domestic sources of corrosion. Other relevant contaminants that contribute to the formation of corrosive environment include microorganisms, ammonia and green house gases. Many of such gases accumulate in the atmosphere and return to the ground in the form of acid rain which causes corrosion of metals[6-8].

The serious consequences of the corrosion have become a constant and continuous problem of worldwide significance, leading to huge economic, social and environmental losses. Several studies over the past years have shown that a substantial portion of national wealth

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approx. 2-4% of GNP in India is being lost by way of corrosion every year[9-11]. Besides this, the possible harm to the surroundings as well as to the people is beyond interpretation. Escape of products through leaked corroded containers, drinking water and oil transportation in corroded pipelines generate severe accidents and toxicity. Moreover, packaging food in corroded metal container becomes toxic and unsuitable for consumption[12]. Worldwide, the corrosion of metals causes considerable waste of natural resources; hence, its study is imperative.

Among various metals, aluminium (Al) is the second largest used metal next to iron with great technological significance for widespread application varies from household to engineering, packaging and building. The high consumption is attributed to the properties of Al such as lightness, strength, durability, high electrical and thermal conductivity as well as its ability to form a natural oxide layer to protect its surface[13-15]. The resistance and stability of the oxide layer is a function of the corrosive environment and metal composition, depending upon which it is susceptible to different types of corrosion such as uniform, filiform and pitting corrosion[4-8]. Al shows high rate of corrosion when plunged into a wide variety of corrosive environment and basically more prone towards pitting corrosion under saline (NaCl) environment. The effect of oxygen and chloride cause the localized attack where the oxide film break down and the chloride ions reach the Al surface to form pits[16-17].

MATERIALS AND METHODS

Aluminum ribbon (> 99 %, Si 0.02, Cu 0.005, Fe 0.006, Mn 0.002, Zn 0.005, Ti 0.005, As 0.0002 and N 0.005 Merck) was cut into the square shaped dimension of $2cm^2$ area and finished with an emery paper (mesh size 320600). Sodium chloride (NaCl) solution (0.5M, pH 5.5) was prepared in deionized water ($5.4X10^{-8}$ ohm^{-1}) and used as electrolyte for electrochemical experiment. The electrochemical experiment was conducted in a three electrode cell assembly with reference to saturated standard calomel (Hg/Hg_2Cl_2) electrode. Pt foil with $1cm^2$ area was used as counter electrode and the Al electrodes were served as a working electrode. All measurements were performed after immersing the Al electrodes at working area of $1cm^2$ in freely aerated stagnant NaCl (0.5M, pH 5.5) at room temperature. Cyclic voltammogram (CV) @ 0.015 to 0.025V/s were recorded in the potential window of -0.18 to 1.0V at 1μA. Electrochemical impedance spectroscopy (EIS) was recorded under open circuit potential up to 2hrs of immersion. An alternating voltage of 0.025V with sweeping frequencies between 10000Hz to 1Hz was coupled to a frequency response analyzer to acquire Nyquist and Bode plots @ 4 points per decade change in frequency, fitted to an equivalent circuit. The Tafel plots were obtained from 0.1V to 1V with potentiodynamic polarization measurement at different scan rate of 0.001, 0.01 and 0.1 V/s.

RESULTS AND DISCUSSION

Aluminum electrode display reproducible CV curves in NaCl (0.5M, pH 5.5) till 5cycles at potential range -1.3 to -0.9V @ 0.015 to 0.05 V/s (Fig 1). The characteristic semicircular loop was appeared in the Nyquist plot within 1hr of immersion due to the formation of oxide layer over the Al surface (Fig 2). The polarization resistance Rp (Ω) was 86.83 at initial hr, which increased to 169.90. The opening of loop at 1.5hr attributes to the destruction of the oxide layer causing pitting corrosion over Al surface with decrease in resistance. The equivalent circuit model common to Al in NaCl show electrochemical system of metal/oxide layer/electrolyte with the solution resistance (R1), oxide layer capacitance (Q1), polarization resistance (R2), double layer capacitance (Q2) and Warburg's impedance (W) (Fig 2 inset). The model represents dissolution of Al surface where the Q1/R2 attributes to the resistance due

to deposition of oxide layer and Q2/W based on double layer capacitance and the diffusion. The unit numerical value of the constant-phase element indicates that the component is an ideal capacitor and represents the capacitance associated with the double layer. The low frequency Warburg response is probably due to the intermediate species generated during the dissolution of Al, which are then adsorbed or precipitated on the surface forming a layer. The dissolution is thus limited by the formation of this layer[18-19].

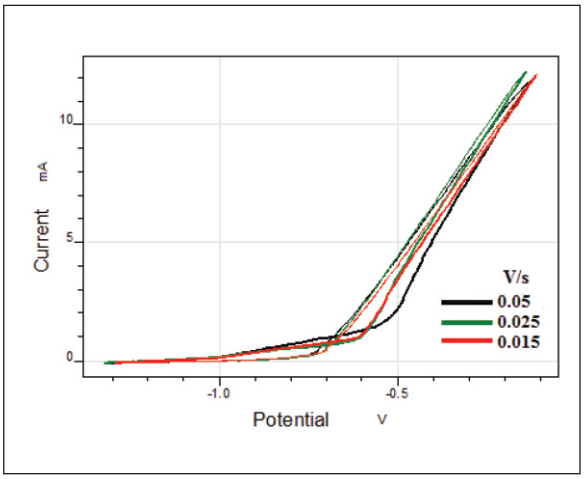

Fig 1: CV of Al in NaCl

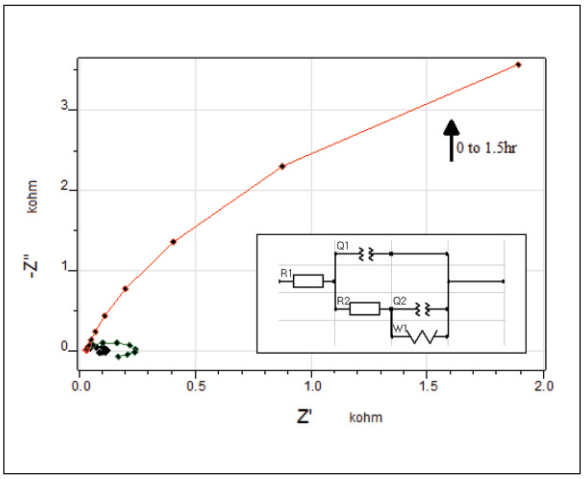

Fig 2: Nyquist plot of Al in NaCl with equivalent circuit model (inset)

The impedance modulus |Z| from bode plot is 89.82Ω at initial hr, which is fairly sensitive to the increase of exposure time (Fig 3). The single time constant, observed for short exposures, may be assigned to the corrosion reaction of the exposed metal. As the exposure time increases, the evolution of pitting corrosion appears with remarkable reduction in the impedance[20-21].

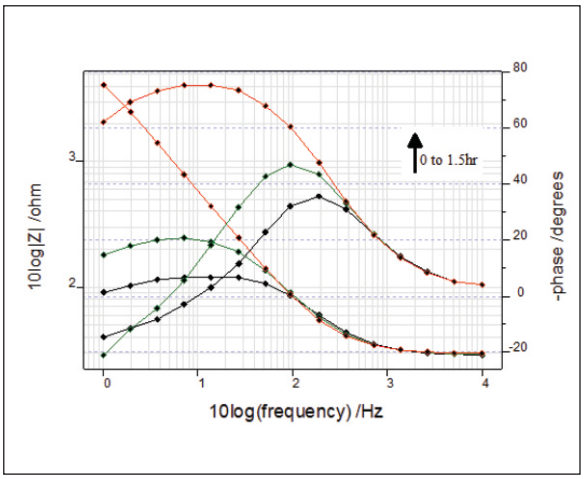

Fig 3: Bode plot of Al in NaCl

Tafel plots (Fig 4) indicate that with increase in scan rate (V/s) from 0.001 to 0.1, a simultaneous

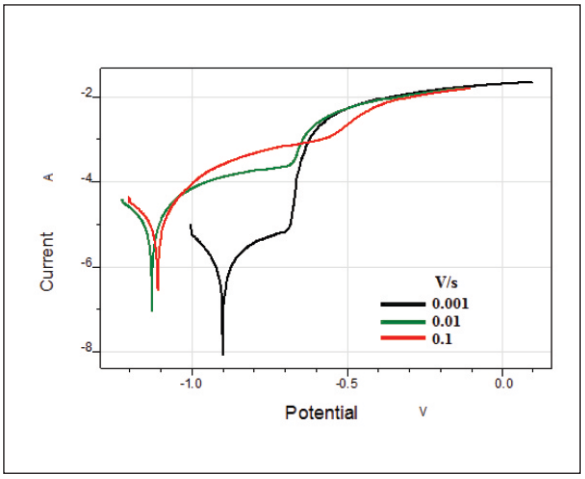

Fig 4: Tafel plot of Al in NaCl

current due to the breakdown of passive oxide layer. The surface characteristic was revealed through SEM indicating the formation of pits with oxidation of Al (Fig 5)[22].

Table 1: Tafel data of Al in NaCl at different scan rate

Parameters	0.001 V/s	0.01 V/s	0.1 V/s
Ecorr V	-1.20	-1.09	-1.17
Icorr A/cm^2 X 10^{-4}	3.46	0.04	0.25
Rp Ohm X10^3	0.12	8.11	1.77
ba V/dec	0.59	0.19	0.34
bc V/dec	0.11	0.13	0.14
C Rate mm/y	1.13	0.9	0.8

Mechanism - Pitting is a highly localized type of corrosion in the presence of chloride ions where pits are initiated at weak sites of the oxide film by chloride attack. The Al metal is oxidized to Al ions, which attract the chloride ions from the surrounding environment towards the pit bottom to form $AlCl_3$. The hydrolysis of $AlCl_3$ reduces the pH value at pit bottom and the resulting HCl formation inside the pit causes accelerated pit propagation.

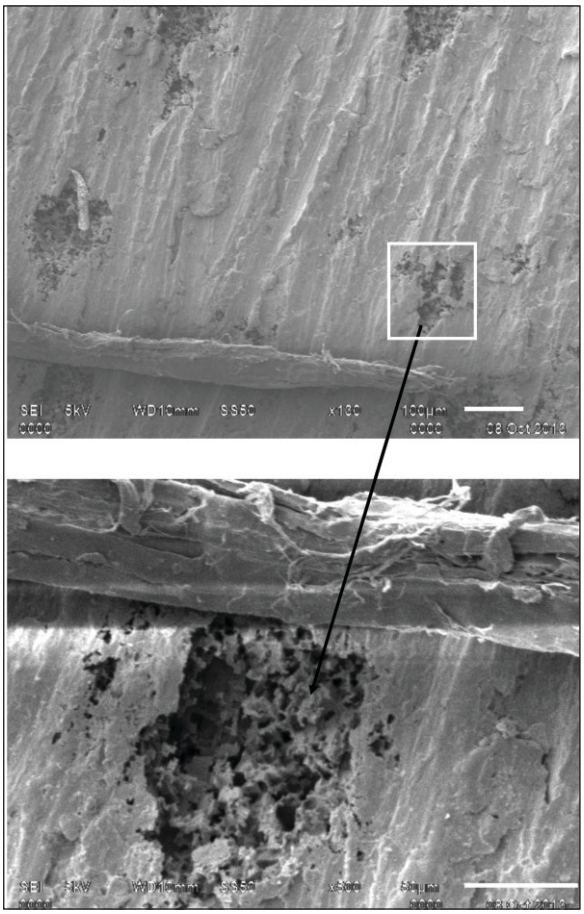

Fig 5: Surface characteristics of Al in NaCl

$$Al \rightarrow Al^{3+} + 3e- \quad \text{Eq 1}$$

$$Al^{3+} + 3Cl^{-} \rightarrow AlCl_3 \quad \text{Eq 2}$$

$$AlCl_3 + 3H_2O \rightarrow Al(OH)_3 + 3H^{+} + 3Cl^{-} \quad \text{Eq 3}$$

Aluminium ions diffuse to the opening of the pit where the environment is more alkaline and Al(OH)3 is formed at the top of the pit which reduces the entry of the corrosive electrolyte to the pit and the pits are re-passivated[14-22].

CONCLUSIONS

Corrosion, is what we are least concerned about, has many serious economic, health, safety, technological and cultural consequences to our society. It is necessary to translate the focus towards the effect of environment on corrosion behavior of metals. The study done was not only to provide knowledge but to raise the awareness regarding the importance of ecological considerations because metallic resources are being overexploited and the environmental impact resulting from any failure in service is unpredictable. Hence, corrosion management involving science, engineering and technology is essentially studied to mitigate its effect in society and to reach a possible equilibrium between corrosion and sustainability.

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International Journal on Environmental Sciences **6** (2) : 287-291, July-December 2015 **Research Article**
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Effect of Occupational Exposure on the Incidence of Health Profile in Tannery Workers

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ABSTRACT

Chrome tanning is still the most economically advantageous method to produce good quality leather. Chromium has been recognized as one of the most effective tanning agents and has been widely employed in the leather industry since its discovery more than 100 years ago. Since then, some 85 % of the leather produced worldwide is tanned with chromium salts, either alone or in combination with other tanning agents. There are several potential sources of air emissions in the leather tanning and finishing industry such as chromium emissions that may occur from chromate reduction, handling of basic chromic sulphate powder and from the buffing process. All the data was subjected to statistical analysis and chi-square test. More than 75% of women are engaged in tanning. Simultaneously 182 control subjects were selected with age group 15-65 years. The workers were employed for 6-30 years. They were had the sign and symptoms of exposure effects on chronic Bronchitis, eye irritations, headaches, backaches, as the significant increase in Joint pains. The studies showed industrial workers are at high health risk group combined action of local authority's society and international bodies may help chromium related health problems.

Keywords: Chromium, Carcinogen, Exposure, Occupational.

INTRODUCTION

In India, the Sukinda vally of odisha contains 98% of countries chromite deposits and is considered as one of the prime open cast chromite or mine of the world over an area of app. 200 sq. km in Jaipur district, India and it is known as Blacksmith Institute of pollution Report 7, Chromite mine workers are reported to be suffering from gastro intestinal bleeding, tuberculosis, and asthma are common ailments infertility, birth defects and still birth have also been resulted in constantly exposed to contaminated dust and water.

Chromium is produced from the ore chromite and is mainly used in metallurgy (production of stainless steel and alloys), refractory (production of bricks for furnaces) and chemical industries (pigments, wood preservatives and tanning leather) (Adriano *et al.,* 2001). Leather tanning is the process of converting raw hides of skins into leather

Cr (VI) and its intermediates can interact directly with DNA to form complexes that results DNA-protein and DNA-amino acid cross links, which in turn may effect DNA replication, DNA damage, gene mutation and gene expression. Concentrations of chromium in blood, serum, urine and hair have long been used in biological monitoring of environmentally and

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occupationally exposed populations, as a biomarker of exposure. Occupational exposure to Cr III, used in tannery industry increase the risk of ulcer, dermatitis, lung and Sino, esophageal, pancreatic cancers. The incidence of lung cancer morbidity is 21.6 times in K2CrO7 exposed worker than control population. Leather dust is carcinogenic to humans and classified as group-1 carcinogen [Xie *et al*, 2004, Kurt Straif, 2010] Incidence of respiratory tract problems were higher in Aligarh lock factory workers (Hasan *et al* 2002)In a retrospective epidemiological study conducted in South easten coal mines showed the occurrence of pneumoconiosis was about 3% in India (Parihas *et al* 1997) Further Jyosna reported higher incidence of respiratory tract health problems due to coal dust inhalation. Occupational health problems causing health problems are elevated in exposed to lead based paints (Madhavi and Rudrama Devi, 2011) The exposures within the leather tanning industry have been suggested by some investigators to result in the development of a variety of specific cancers including lung, bladder, kidney, pancreatic oral cavity, nasal and soft tissue sarcoma and skin along with dermatitis, ulcers, perforation of the nasal septum, respiratory illnesses (rastogi *et al*, 2007).

MATERIALS AND METHODS

Study population

The chromium exposed group comprising of 194workers out of 600 employees in the industries having duration of services ranging from 16-66 years who worked for 8 h/per day were selected. The workers were further divided into groups based on the duration of exposure, life style, diet, socio-economic status and habits for comparison, 180 age matched subjects belonging to same socio-economic group as that of workers were selected to serve as control subjects who are not exposed to any toxic chemicals. Various symptoms such hypertension, chronic bronchitis, eye irritation, headache, backache, asthma, fatigue, skin allergy, joint pains were recorded for the study in control and exposed population. The data was analyzed by Chi-square test.

Table 1: Summary of clinical data

SYMPTOMS	CONTROL (164)	CHROMIU Mexposed group (210)
Hypertension	18(10.20)	24(11.42)
Chronic bronchitis	22(13.41)	38(18.09)
Eye irritation	14(8.50)	20(9.52)
Headache	22(10.50)	24(11.42)
Backache	16(9.75)	30(14.38)
Asthma	18(10.97)	26(12.38)
Skin allergy	17(10.36)	24(11.42)
Fatigue	16(8.50)	20(9,52)
Joint pains	21(10.00)	34(16.19)

RESULTS AND DISCUSSION

Various symptoms such as hypertension chronic bronchitis, eye irritation, headache, backache, asthama, fatigue, joint pains were recorded for the study. The percentage of health problems

like chronic bronchitis eye irritation [12.82%], backache [12.80%], asthma [8.9 %], skin allergy[10.25%]and joint pains [23.67%] were higher in exposed to tobacco dust through inhalation against the complaints found in general population [control group], the differences in percentage of Health profiles between control and exposed groups were analyzed statistically using Chi-square test. Workers employed in leather tanning companies may be exposed to higher-than-normal levels of chromium, mostly trivalent chromium (Cr(III)) (Life Systems Inc *et al.*, 2008), either in the form of inorganic Cr (III) compounds or as Cr bound to protein (leather dust) (Stupar *et al.*, 1999). Toxicity for Cr (III) is very low, even when present in very large quantities, while hexavalent chromium (Cr (VI)) has been found to be biologically active. The failure of Cr (III) ions to pass the cell membrane explains the genetic inertness of Cr (III). Nonetheless, some data suggest that in mammalian cells endocytosis allows Cr (III) complexes to pass through the membrane barrier and enter cells. Cr(III) compounds are 1000-times less toxic than Cr(VI) compounds (Life Systems Inc *et al.*, 2008), but may cause toxicity at higher concentrations and/or depending on its ligand (Bagchi *et al.*, 2002).

Relatively few studies are available in the literature that directly address the toxicity of Cr(III), particularly exposure through inhalation. This lack of data results in considerable uncertainty regarding the hazard associated with exposure to Cr(III) (Grevatt and United States. Environmental Protection Agency, 1998; Medeiros *et al.*, 2003). Concentrations of chromium in blood, serum, urine and hair have long been used in biological monitoring of environmentally and occupationally exposed populations, as a biomarker of exposure (Simpson and Gibson, 1992; Rajaram *et al.*, 1995; Grevatt and United States. Environmental Protection Agency, 1998; Stupar *et al.*, 1999; Medeiros *et al.*, 2003).

Tannery workers have been known from previous studies to have the potential for exposure to numerous known or suspected occupational carcinogens including hexavalent chromium salts, arsenic, organic solvents (benzene, formaldehyde, butyl acetate, ethanol, aceto-acetate, toluene and acetone). The two major sources of chromium particulates in the tannery work environment are chromium chemicals used in the tannery work environment are chromium chemicals used in the tanning process in the form of Baychrom and Cr (OH) SO_4. Chromium, which is a basic tanning agent, is available in trivalent form as chromium sulphate and in inorganic form and in the protein bound form that is known as leather dust. The leather dust produced by mechanical operations i.e., buffing and shaving, contains 3% of mostly protein bound chromium. In our National context, environmental hazard of chromium and related chromium industrial operations are of great concern. This industry is fragmented across the state with about 138 manufacturers and several others employing about 2.5 million workers spread all over India. Own raw material source - 21% of world cattle & buffalo and 11% of world goat & sheep population are housed in India. 2 Billion sq. feet of leather produced annually. The workers environment is highly polluted with chromium and continuous exposure over long periods of work place is of utmost importance.

A study in assam reveals that affected paddy field workers develop exanthema on the exposed parts of their skin mainly legs and arms when they come in contact with water and rice fields (Narain 1994). A very high respiratory morbidity was recorded in mango plantation workers exposed to prolonged inhalation of organic dusts during the farming operation (Gupta 1995).

Futher an increase in the deterioration of lung function was observed in Tamil nadu among asbestos exposed workers in a manufacturing

unit (Gautham et al 2003). Adult carpet weavers in Mirzapur also reported respiratory problems as major occupational risk who are exposed to carpet dust particles (Das *et al* 1992). Further as child labour is high in India ,the children employed carpet industry in Jaipur city showed acute respiratory problems compared to normal children live in same community which is associated with cotton dust [Joshi *et al* 1992] high incidence of lung cancers were reported in workers exposed to leather dust (rastogi *et al* 2007) dental problems were high in tannery workers (Priti Sharma 2012).

Among working children acute physical pains were recorded in leather industry exposed to glue and solvents [Mitra 1993]. The health problems like coughing, sore throat, dizziness, methemoglobinemia and anemia are common effects of ingestion and inhalation of chlorate dust in child labor of sivakasi (Sekhar, 1992)

Evidence from cohort study conducted on health care providers in Telangana shown an association between occupation [hospital staff] and incidence of malaria. The risks are four fold in nursing students and two fold among medical students than well trained doctors Rajasekhar Nanda Kumar (2000)., due lack of precautions. Elevated risks of hepatitis B infections were reported in hospital personnel in West Bengal (Baltacharya, 2001). A study based on traffic policemen showed respiratory tract problems exposed to benzene from six major towns of north India (Verma 2003).

CONCLUSIONS

Over all, the report highlights that the tannery workers, occupationally exposed to chromium, have showed higher risk of severe health problems when compared to controls population.

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Studies on the Distribution Pattern of Freshwater Gastropods of Porur Lake, Chennai

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ABSTRACT

Increasing awareness on the importance of biological diversity and environment conservation, for the future of mankind, it has become necessary to estimate the resource available and to understand the structural and functional significance of the species. Molluscs are conspicuous and abundant in any productive aquatic ecosystem and can be considered as treasures within arms reach. The impact of threats to molluscan biodiversity is complicated by limited knowledge of the freshwater mollusc fauna of Tamil Nadu. Since Porur Lake is considered to be one of storage water point of Chennai drinking water supply, it is proposed to study the status of freshwater gastropod diversity (Mollusca) and their distributions in Porur lake. It is known that the gastropods play an important role in transmitting diseases to man and its livestock have to be conducted on their local and seasonal distributions.

In line with these objectives in mind, a total number of 2689 freshwater gastropods were collected in Porur lake during the study period of January to June 2014. The total collection of all the specimens were physically verified. The Class Gastropods was exclusively concentrated, due to more number of specimens are present under this class of Phylum Mollusca.. The gastropods were classified and reported under 17 species of 10 genera 7 families 2 order and two sub classes under Phylum Molusca. A total list of 17 species were recorded and their scientific names were updated. The revalidations of names were done through different information sources. The names were updated according to the current classification. Cataloging has been made for Class Gastropods up to species level and processed through orders, families, genus and species. It is concluded that the information of the faunal diversity of freshwater gastropods may serve as a base line data for the future research with regard to public and veterinary health.

Keywords: Freshwater molluscan diversity – Gastropod diversity – taxonomic status of gastropods – Conservation of molluscs.

INTRODUCTION

Natural history collections play a vital role in our understanding of biodiversity, evolution, population genetics and the environmental impacts of climate change, pesticide use and so on. This is because historical collections provide base line data against which modern observations can be compared and to develop productive models. Our biosphere faces an increasing rate of biological extinctions and ecosystem alterations resulting from human

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impacts. In many cases, species become extinct even before they are described. To maintain, our biodiversity and to understand changes in our environment, we need to sustain our natural history collections. The accurate identification of organisms is essential for providing credibility to the studies and to the publications of result from those studies.

Phylum Mollusca, the second largest of invertebrates next only to the Arthropods, comprises of soft bodied animals. Out of seven classes, Gastropoda is the largest and most diverse class comprising some 65000 to 75000 species including marine, freshwater and terrestrial forms many of which are important to man. Thus, during their evolution, they have become adapted to living in nearly all available habitats. Out of the 415 families in Phylum Mollusca, only 257 families are represented in the Indian subcontinent. Of these, freshwater Mollusca are represented by 210 species under 52 genera and 21 families (Subba Rao, 1993). Temperature, chemical factors, vegetation and nature of substratum play an important role in the distribution of these molluscs. Freshwater molluscs play a significant role in the aquatic ecosystem and many species are sources of food for aquatic animals as well as for human beings (species like *Bellamya bengalensis, Pila globosa, Brotia costula, Angulyagra oxytropas and Lamellidans marginalis and for pearls like Lamellidans marginalis and Lamellidanscorrialis)*. Further, other species of the genus Parrieysia are largely used in the manufacture of shell buttons and poultry feeds.

The need for a stronger focus on invertebrate conservation has long been organized, but the information on the status and distribution of them are not readily available (Groombridge, 1993). The study of molluscs began nearly 200 years ago. Studies on the Indian Molluscs were scattered and scanty. With reference to freshwater Gastropoda, Preston's (1915) Fauna of British India, Mollusca, Gastropoda and Pelecypoda (freshwater) contains the descriptions of several species, 260 species of Gastropoda under 3 order and 10 families belonging to the 40 genera.

There were several researchers attempted on freshwater gastropods in different states of India. In North India, for instances, molluscs of Thar desert (Subba Rao, 1993); in western Himalaya (Subba Rao and Mitra (1995); mollusc in west Bengal (Mitra and Day (1992). Mollusc from Nanda Devi Biosphere reserve (Surya Rao and Mitra, 1997), in Maharastra (Khade and Mane (2012), in rivers of Barak of Assam (Roy and Gupta, 2010), in river Narmada (Kumar and Vyas, 2012), and in Nepal (Gloer and Bossneck, 2013). Patil (2002) studied the mollucan fauna of Renuka Wetland, Surya Rao *et al.*, (2002 a, b) investigated the molluscan fauna of Ujjaini, and also the taxonomic account of the molluscan fauna of Kabar Lake. Patil and Talmale (2005) published a Checklist of Land and Freshwater Mollusca of Maharashtra State. Sharma *et al.*, (2005) attempted to compile the information on the diversity of freshwater snail fauna of Western Uttar Pradesh and Southern Rajasthan (Sharma, 1997).

Ray (1951), Ray and Roy Choudhury (1969) described several new species of freshwater molluscs. Ray (1961) brought out a detailed account on non-marine Mollusca from South India. Zoological Survey of India (ZSI) undertook the following important studies on molluscan faunal diversity, which includes Subba Rao, *et al.*, (1979) gave the distribution pattern of freshwater mollusca of Orissa and of India (Subba Rao, 1993). Subba Rao, *et al.*, (1994) reported about new records of two Pulmonate freshwater gastropods' with description of a new species, *Bulinus indicus*.In South India, Seshaiya (1928, 1929a,b, 1935, 1936a,b & 1940) investigated the freshwater gastropods, similarly in Andra Pradesh, Janakiram and Radhakrishna, (1984), investigated the freshwater molluscs.

From the review of literature, it is observed that information available on the freshwater molluscan fauna from Indian southern state of

Tamil Nadu are very limited. The land and fresh water molluscs in the collection of the Madras government Museum worked out by Satyamurthi (1960). The study by Subba Rao (1989) revealed the presence of 26 gastropod species from Tamil Nadu. In view of the paucity of information on the gastropod fauna, it has become very essential to undertake the studies on the freshwater gastropods. This fact has been stressed by Subba Rao (1991a,b) that the information on the freshwater gastropods on the four southern states including Pondicherry is restricted to only few ecosystems. Hence, an attempt has been made to compile the information on the Freshwater gastropods of Porur lake, Chennai, Tamilnadu. The objectives of present study includes:

- To prepare a clear list of Gastropod species which are prevalent in Porur Lake, Chennai, Tamil Nadu.
- To make consolidate list with suggestions for conservation of molluscs.

MATERIALS AND METHODS

Location of sampling site - Porur Lake

Porur is a vibrant suburb of Chennai located in Thiruvalur district of Tamilnadu. Porur lake is located at 13.03 N and 80.16 E and 52 feet (15 meters) above the sea level (Fig. 1). Porur is one of the primary water resource for people residing in Chennai. It is actually a temporary catchment area connected with Chembarambakkam Lake. The water from Porur lake is pumped to K.K. Nagar double tank and the treated water is distributed to southern part of Chennai. This lake is exclusively used for City water supply augmentation. It acts as a buffer basin for storage and distribution of Veeranam water for the Chennai city.

Method of collection of specimen

Freshwater gastropods were handpicked from the Porur lake during January to June 2014. The fleshy remains of the snails and hermit crabs were removed. After this, the shells were washed in water and with dilute hydrochloric acid to remove the hard outer coat and to reveal the natural colours. Collected specimens were preserved in 90% ethyl alcohol. The shells thus processed have been identified. with the available keys and comparing with the collection of species available at Zoological Survey of India, Chennai. The Collected species were tabulated and described with reference to biodiversity based on Vaught's classification (1989).

Fig 1 : Overview of Porur lake.

RESULTS

Increasing awareness on the importance of biological diversity and environment conservation, for the future of mankind, it has become necessary to estimate the resource available and to understand the structural and functional significance of the species. The need for a stronger focus on molluscan conservation has long been organized, but the information on the status and distribution of them are not readily available. A total number of 2689 Gastropods were collected from Porur lake (January to June 2014) and the collected specimens of gastropods were classified based on manuals and experts from ZSI and they are presented in Table 1.

Classification of Phylum Mollusca

The Molluscs are one of the most important economic groups of organisms in the tropical Indo-West Pacific region, but they are also one of the most taxonomically difficult families to deal with. A major problem in resolving the taxonomy of the Molluscan is that many species

Table 1: Systematic account of the Gastropods reported in the Porur lake, Chennai (Jan. 2014 to June 2014). All the specimens collected fall under Phylum-Mollusca and Class-Gastropoda.

Subclass	Order	Super family	Family	Sub family	Genus	Sub genus	Speices	No. of species
		Viviparoidea	Viviparidae	Bellamyinae	Bellamya	-	*bengalensis* (Lamark, 1882)	16
							typica (Lamark, 1989)	16
							annandalei (Kobelt, 1908)	16
							dissimilis (Mueller, 1774)	67
							micron (Annandale, 1921)	54
			Ampullariidae	-	Pila	-	*globosa* (Swainson, 1822)	9
							Virens (Lamark, 1822)	12
			Bithyniidae	-	*Bithyni*	-	*troscheli* (Paasch, 1842)	25
						Digoniostoma (Annandale, 1920)	*pulchella* (Benson, 1836)	181
					Gabbia	-	*orcula* (Frauenfeld, 1884)	281
							stenothyroides (Dohrn, 1857)	307
							travancorica (Benson, 1860)	414
					Thiara	-	*scabra* (Mueller, 1774)	94

			Cerithioidea	*Thiaridae*	*Thiarinae*			
					Melanoides	-	*tuberculata* (Mueller, 1774)	64
Pulmonata	Basommatophora	*Lymnoidea*	*Lymnaeidae*	–	*Lymnaea*	*Pseudosuccinea*	*acuminata* (Lamark, 1822)	48
							chlamys (Benson, 1836)	46
							gracilior (Martens, 1836)	36
							luteola (Lamark, 1822)	340
		Pulmonata	Pulmonata	Basommatophora	*Gyraulus*	–	convexiusculus (Hutton, 1849)	41
					Segmentina	*Polypylis* (Pilsbry, 1906)	trochoidea (Benson, 1836)	129
			Bullinidae	*Bullininae*	*Indoplanorbis*	–	exutus (Deshayes, 1834)	510
Total number of species identified								*2689*

are similar in morphology, and separation of taxa has been mainly on the basis of fresh colouration. The collected specimens were physically examined. The taxonomic information provided in this report is based on published literatures. It has been recognized that there are seven classes of molluscs namely: 1. Gastropoda, 2. Bivalvia, 3. Scaphopoda, 4. Aplacophora, 5. Polyplacophora, 6. Monoplacophora and 7. Cephalopod. Among the seven classes of Phylum mollusca, the classes, Aplacophora and Monoplacophora are not represented in India. However, gastropods are predominantly present in Porur lake, hence the gastropods population alone was focused in the present investigation.

Class - Gastropoda

Gastropods, including common forms such as snails, slugs, and whelks, occupy both marine and non-marine environments. Most of the gastropods are classified based on the characteristics the gill structures and other soft-bodied features. Few distinguishing characters of the univalved shell are used in classification as many are the result of convergent evolution. These collections are seats of permanent information storage and unique scientific records of biological diversity of organisms.

A scientific name becomes valid when it is published according to the code of nomenclature. There is a clear difference between the valid name and available name. The latter denotes that the

name is properly published according to the requirement of the code. The valid name denotes that it is not preoccupied by a senior synonym or homonym and it is published in accordance with the provision of the code. The catalogue and check lists are extremely useful to know how many species or the genera reported earlier from an area.

In the present study, a total no of 17 species under 10 genera of 7 families of 2 order and two sub classes were identified. The detailed list of species along with number of specimens collected during the study period is presented in Table No. 1 and Fig. 5. Family Viviparidae is represented with three species viz. 1. *Bellamya bengalensis form typica* (Lamarck) and form annandalei (Kobelt) 2. *Bellamya dissimilis* (Mueller) 3. *Bellamya micron* (Annandale). Family Ampullaridae represented with two species of *Pila globosa* and *Pila virens* under single genus. Family Bithinidae with Two genera of *Bithinia* and *Gabbia* along with one subgenus under *Digoniostoma* of five species were recorded from the study area.

Two species of *Thiara (Thiara) scabra* and *Melanoides tuberculata* were recorded under the family Thiaridae. Family Lymnaeidae under genus *Lymnaea* along with subgenus-*Pseudosuccinea* species *acuminata* form *typica*, form *chlamys*, form *gracilior* and *Lymnaea* (*Pseudosuccinea*) *luteola* form *typica* were collected and recorded. *Gyraulus convexiusculus* along with genus *Gyraulus, Segmentina* (*Polypylis*) trochoidea genus Segmentina subgenus- Polypylis as under family *Planorbidae*, *Indoplanorbis exutus* under family Bullinidae were recorded. The percentage of Family wise, genera wise and monthly wise number of gastropods collected on all the seventeen species were given in Fig. 2-5. The detailed list of species along with synonyms, material examined, diagnostic characters and their distribution status are presented elsewhere (Karthick, 2014).

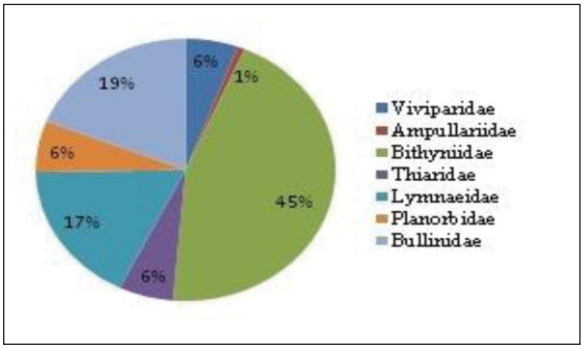

Fig 2 : Familywise distribution of Gastropodes

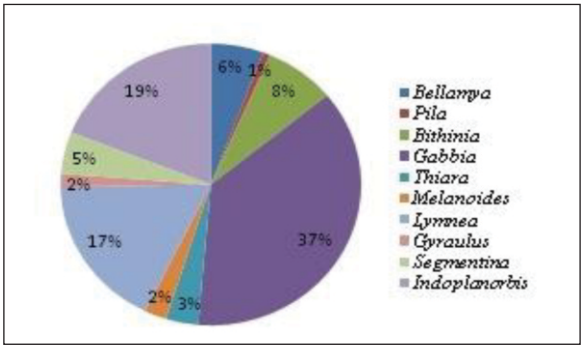

Fig 3 : Generawise distribution of Gastropods

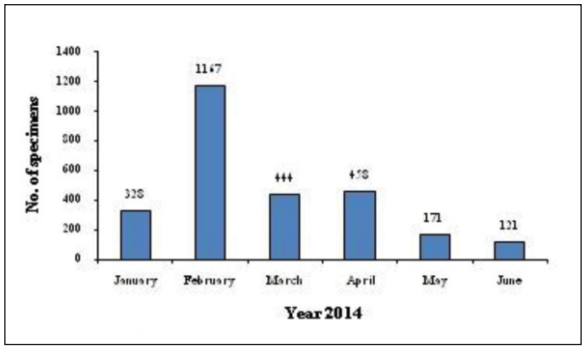

Fig 4 : Monthwise distribution of Gastropods

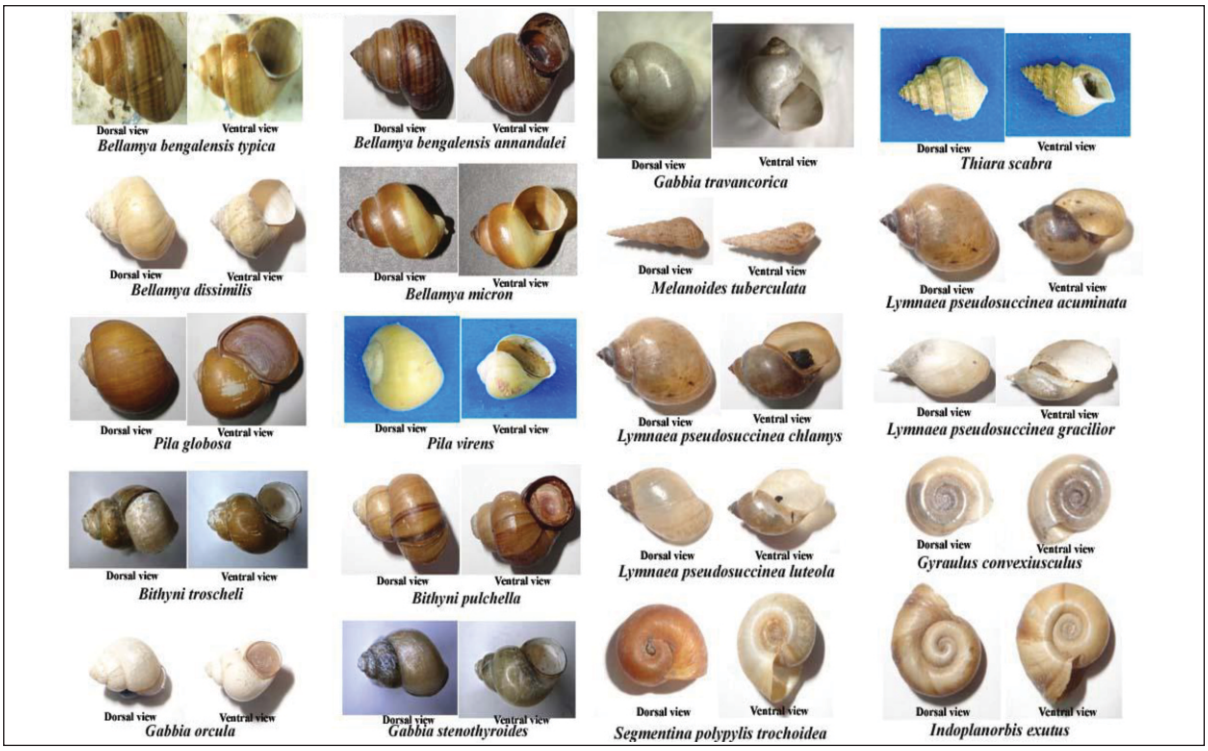

Fig. 5 : Freshwater gastropod diversity in Porur lake.

DISCUSSION

A total of 2689 specimens of gastropods were collected during the study period from the Porur lake. The maximum number of specimens (1167) was collected during summer month of May, 2014 comprising of 14 species as maximum and the minimum number of 3 species was encountered during the month of June 2014. *Bithynia* (*Digoniostoma*) *pulchella*, *Gabbia orcula* were continuously collected and recorded for the entire study period. Pila globosa was recorded with minimum of only 9 specimens on 4 occasions. *Indoplanorbis exutus* was collected with maximum number of gastropods (510) in May 2014. Based on the numbers of collected gastropods, the number of species identified in Porur lake were shown in Table 1.

The present result agrees with Karimi *et al.* (2004) where they found that late Summer and Autumn had the optimal temperature required for breeding and reproduction of snails, and partially agrees with El-Kady *et al.* (2000); they stated that April, May and June showed the highest number of snails in Sinai Peninsula, while the lowest number was recorded during January and February. Van Schayck (1985) reported that the snails are not directly dependent on aquatic plants but they may prefer a habitat with aquatic vegetation. However, Utzinger *et al.* (1997) concluded that the distribution of freshwater snails is a result of more complex interactions of different habitat factor. However, Imfidon (1991); Agi (1995) and Agi & Okwuosa (2001) reported that freshwater snails are known to exhibit high degree of tolerance and adaptation within a reasonable range of physicochemical fluctuation.

The present study shows that gastropod communities found to inhabit the Porur lake in different months represented by a range of

species. It might, therefore be useful and to investigate the contributions of these macro invertebrates towards nutrient processing and explore their role as bio-monitors. This study revealed that the densities of the recorded freshwater gastropods at Porur lake underwent changes in numbers in different months of study period. Several environmental factors appear to affect the snail populations, in particular, the presence or absence of the aquatic weeds which may be cleaned to reduce the populations of snails. Further, the construction of flyover over the lake affected the ecosystem. In addition, the water from Veeranam lake (200 km south of Chennai) is regularly pumped in to Porur lake, for the augmentation of water supply to city, which affect the physic-chemical water quality, consequently affected the density of gastropod population in the freshwater ecosystem.

However, the information on the number of gastropod species in land and freshwater molluscs from other parts of the country, showed that Jammu and Kashmir (89); Himachal Pradesh (29); Rajasthan (28); West Bengal (185); Orissa (71) and Pune (Maharashtra) (130) are available (Subba Rao *et al.*, (1989). Based on the study in West Bengal, 38species of freshwater gastropods belonging to 8 families under 12 genera were reported by Mitra and Day (1992). Surya Rao and Mitra (1997) reported 13 species belonging to 6 families from Delhi under following genera *Bellamya, Digoniostoma, Gabbia, Thiara Lymnaea, Indoplanorbis, Gyraulus, Segmentina* and *Physa*. In Renuka wetland area, 7 species of gastropods belonging to 4 families of genera *BellamyaThiara, Lymnaea, Indoplanorbis* were reported (Surya Rao and Mitra, 2000). In the Sikkim state, 4 species belonging to 3 families under 3 genera were reported (Dey *et al.*, 2003). A report on Pench National Park comprises of 23 species belonging to 6 families under 9 genera were reported (Patil and Ramakrishna, 2004).

Based on the study made from Desert National Park, 4 species belonging to 4 families under 4 genera were reported (Surya Rao *et al.*, 2004). This present study also falls in the same lines of the above referred reports, with 17 species under 10 genera of 7 families of 2 order and two sub classes of Phylum Mollusca from Porur lake as first of its kind. Freshwater mollusks have been known to play a significant role in the public and veterinary health, Hence, it is necessary to identify the intermediate hosts for the diagnostic of trematodes parasites since the family Thiaridae were recorded to harbor larval trematodes. Therefore, this present study elucidate the distribution of intermediate hosts belong to the families of Planorbidae and Lymnaeidae in the urban area of Chennai. It is concluded that the information of faunal diversity of freshwater gastropods may serve as a base line data for the future research interms of public and veterinary health aspects.

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International Journal on Environmental Sciences **6** (2) : 303-310, July-December 2015 **Review Article**
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Trend of Rainfall in Different Sectors of Uttar Pradesh Under Present Scenario of Climate Change

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ABSTRACT

In the changing scenario of climate the present study was carried out to identify the recent trend of rainfall variability in different sectors of Uttar Pradesh. Analysis of rainfall (1971-2011) was made for four sectors viz. eastern, western, central and bundelkhand region of U.P. It was found that in general, annual rainfall decreased in all sectors of U.P. but the rate of decrease of rainfall in western U.P. was faster as compare to other sectors of U.P. and was in the order of western U.P.> eastern U.P.> central U.P.> bundelkhand region. Variability of seasonal rainfall in different sectors of U.P. was also in same order and magnitude as that of total rainfall. Average onset date of south west monsoon in eastern U.P. and central U.P. shifted to 19th/20th June from normal date i.e., 15th June. Total rainfall in relation to onset of monsoon, decreased by 6 percent, if monsoon reaches on 19th June in eastern U.P. as compare to rainfall of normal date (15th June) and 9.5 percent if monsoon reaches on 25th June. Consequent upon length of rainy season was also decreased from normal 108 days to 99 days in eastern U.P. whereas reduction in length of rainy season in other sectors of U.P. ranged between 12-13 days. Rainy day and rainfall intensity both reduced in all sectors of U.P. In eastern U.P. rainfall intensity reduced from 25 mm/day (1971-1990) to 17.2 mm/day (1992-2011), i.e. 32 percent reduction hence crop planning may be made accordingly in respective sectors.

Keywords: Seasonal rainfall, Rainy days, Rainy season, Yield gap.

INTRODUCTION

Agriculture and related sectors, food security and energy security of India are crucially dependent on the timely availability of adequate amount of water and a conducive climate. The rainfall received in an area is an important factor in determining the amount of water available to meet various demands, such as agriculture, horticulture, livestock, industries and domestic water supply etc. Global climate changes may influence long-term rainfall patterns impacting the availability of water, along with the risk of increasing occurrences of droughts and floods. The southwest (SW) monsoon, which brings about 80% of the total precipitation over the country, is critical for the availability of freshwater for drinking and irrigation. Changes in climate over the Indian region, particularly the SW monsoon, would have a significant impact on agricultural production, water resources management and overall economy of the country. The heavy concentration of rainfall in the monsoon months

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(June–September) results in scarcity of water in many parts of the country during the non-monsoon periods. Change in rainfall due to global warming or after 1990's (after industrialization) in the country, may influence the hydrological cycle and rainfall pattern. This compelled to review the demand of water hydrological design and agricultural practices. Therefore, long term trend analysis of rainfall and other weather parameters on different spatial scales will help in framing, the future scenarios for crop planning and management (Jain & Kumar 2012).

Data and Methodology

The districts wise rainfall data of 20 years (1992-2011) on daily basis of sectors of U.P. was obtained from State Agriculture Department, Lucknow. Rainfall variability, characteristics of rainfall, length of rainy season, onset/withdrawal of monsoon and time series analysis of rainfall and its relation with productivity was done using step wise regression technique. District wise historical data of rice area, production and yield for period of 1992-2011 of U.P. was obtained from State Agriculture Department of Lucknow. Time series graphs were plotted for trend analysis of area, production and productivity of rice for each sectors of U.P. The data has been analyzed to evolve the rainfall based planning the farm operations, crop management and cropping system with minimum risk to utilize the rainfall efficiently for increased production.

RESULTS AND DISCUSSION

Annual rainfall

Based on time series data (1992-2011) of average annual rainfall for different sectors of U.P., annual rainfall in Bundelkhand region was minimum (663 mm) followed by Western U.P. (750.9 mm). eastern U.P. received highest amount of rainfall (902.3 mm) followed by central U.P. (790.2 mm) (Table 1). The variability and trend of annual rainfall for these sectors has been depicted in Fig. 2 and it was observed that annual rainfall in all sectors of U.P. decreased in recent years. The rate of decrease of rainfall in western U.P. was highest and Bundelkhand region of U.P. was lowest. The rate of decrease was in order of western U.P.> eastern U.P.> central U.P.> bundelkhand region of U.P. But if time series data is grouped into two parts, i.e. (i) 1971 to 1991 and (ii) 1992 to 2011, the recent trend of rainfall as observed from time series analysis of 1992-2011 was specific and peculiar in the sense that the rate of decrease of rainfall in Bundelkhand region of U.P. was highest instead of western U.P. as observed in combined time series analysis of 1971-2011. This shows that the western branch of the SWM after Kerala onset and western disturbances affected the south-west monsoon to the great extent in western and bundelkhand region of U.P.

Table 1: Average annual rainfall of different sectors of Uttar Pradesh.

Sectors	Average annual rainfall (mm)
Eastern U.P.	902.3
Central U.P.	790.2
Western U.P.	750.9
Bundelkhand region of U.P.	663.0

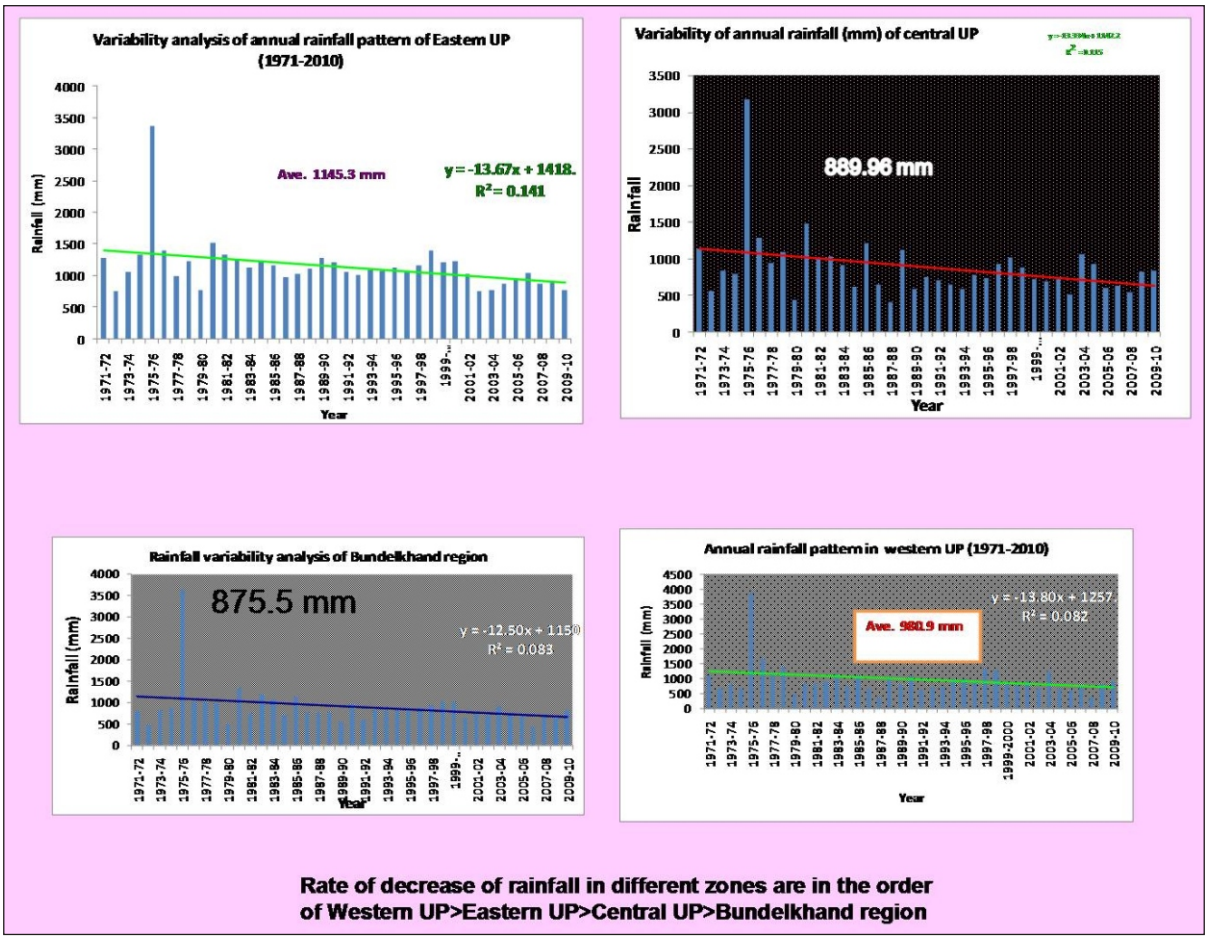

Fig. 1: Variability in annual rainfall pattern for different sectors of U.P. (1971-2010).

Seasonal rainfall

Average rainfall during south-west monsoon season in eastern U.P. was 29% followed by central U.P. (25%) and western U.P. (24%) and Bundelkhand region (22%) (Fig 2). The highest rainfall percentage, i.e. 34% was obtained in eastern U.P. during post monsoon season followed by central U.P. (26%), western U.P. (22%) while minimum rainfall during post monsoon season was received in Bundelkhand region of U.P. (22%). The lowest rainfall (16%) was received during winter season in Bundelkhand region. Highest percentage of rainfall was recorded in western U.P. (35%) followed by central U.P. (26%) and eastern U.P. (23%). The partitioning of rainfall during summer season was in order of western U.P. (30%) followed by central U.P. (28%), eastern U.P. (25%) and Bundelkhand region (17%). From the above analysis it may be revealed that due to higher rainfall percentage in western U.P. during winter season and summer season, the rabi and summer crops may be harvested at higher economics and yield hence good return.

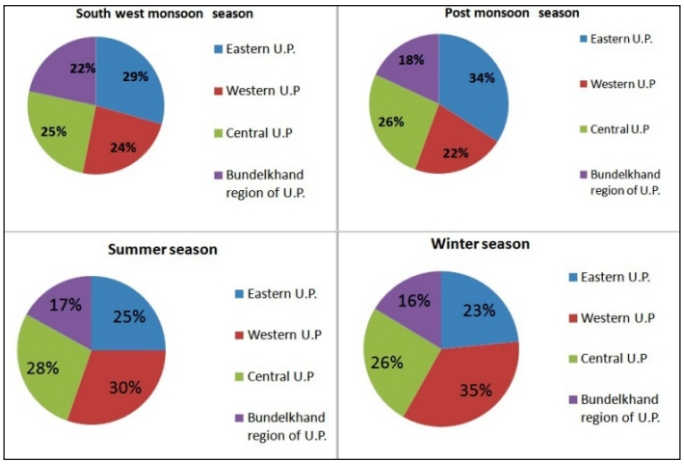

Fig. 2: Seasonal rainfall partitioning under different sectors of U.P.

Onset /withdrawal dates of monsoon and length of rainy season

Onset/withdrawal dates of monsoon and length of rainy season in different sectors of U.P. has been shown in table 2. The average onset date of south-west monsoon in eastern U.P. and central U.P. was shifted to 19 June from normal onset date followed by Bundelkhand region of U.P. (20 June) and western U.P. (21 June). Normal onset date in eastern U.P. is 15th June and that in western U.P. 17th June. The onset date in U.P. delayed 4 days from the normal. The yearly variation of onset and withdrawal dates and length of rainy season in different sectors of U.P. has been shown in table 3. It has been observed that in different years, the range of onset date of south-west monsoon in eastern U.P. and central U.P. was in between 8th to 26th June, whereas in western U.P. and Bundelkhand region, it lies between 9th to 27th June. i.e., one days ahead from eastern U.P./ central U.P. This shows that monsoon covers entire U.P. within one day from east to west. Withdrawal date of south-west monsoon in different sectors of U.P. was 21st September except eastern U.P. where, average date of withdrawal was realized as 25th September against the normal date 30th September. The withdrawal of south-west monsoon shifted 5-9 days early toward rainy

Table 2: Onset/withdrawal dates and length of rainy season during south-west monsoon period.

Sectors	Onset date of SWM (June)	Withdrawal date of SWM (Sep.)	Length of rainy season of SWM (days)	Deviation from normal
Eastern U.P.	19 (15)	25 (30)	99 (108)	-9
Central U.P.	19 (16)	21 (30)	95 (107)	-12
Western U.P.	21 (17)	21 (30)	93 (106)	-13
Bundelkhand region of U.P.	20 (17)	21 (30)	94 (106)	-12

*Figure in parentheses shows the normal dates/days as per IMD, Govt. of India.

season. Length of rainy season was therefore, drastically reduced from normal 108 days to 99 days in eastern U.P. i.e., 9 days, whereas reduction in length of rainy season in other sectors of U.P. ranged between 12 to 13 days. This ultimately forced to reconsider the crop planning and selection of rice crop varieties of short duration as to minimize the risk losses.

Table 3: Onset and withdrawal dates of south-west monsoon in different sectors of U.P.

Year	Eastern U.P.		Central U.P.		Western U.P.		Bundelkhand region of U.P.	
	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)
1992	21	24	23	22	27	25	25	27
1993	23	27	19	27	21	24	27	25
1994	20	20	25	19	23	18	24	16
1995	20	24	19	22	20	16	18	20
1996	20	29	20	19	24	20	18	15
1997	20	25	19	22	18	27	18	26
1998	24	27	16	25	28	26	20	26
1999	21	27	23	27	24	25	23	24
2000	15	25	16	21	16	15	12	21
2001	18	19	13	17	17	19	20	8
2002	12	25	23	20	9	20	19	20
2003	22	28	21	28	20	20	24	30
2004	15	25	19	22	20	23	15	22
2005	23	25	18	24	25	26	24	22
2006	26	26	25	16	25	12	22	17
2007	17	29	15	28	18	27	24	28
2008	8	26	14	25	11	21	11	25
2009	24	16	26	12	25	12	23	15
2010	25	22	21	22	26	27	26	23
2011	18	25	19	14	19	22	21	23
Total	392	492	382	428	418	420	407	428
Average	19	25	19	21	21	21	20	21

Rainy days and rainfall intensity in different sectors of U.P.

The rainy days and rainfall intensity of different sectors of U.P. has been shown in table 4. The number of rainy days in different sectors of U.P. ranged from 40 days in Bundelkhand region to 48 days in eastern U.P. during south-west monsoon period whereas it was almost same and ranged between 15.4 mm/day in Bundelkhand region to 17.2 mm/day in eastern U.P. Intensity of rainfall in Central U.P. was 16.4 mm/day, within 41 rainy days however, in western U.P. it was 15.6 mm/day in 45 days and in Bundelkhand region it was at par with central U.P. i.e., 41 rainy days 40 days. From the data, it was revealed that rainy days and rainfall intensity both were reduced in all sectors of U.P.. In eastern U.P. rainfall intensity reduced from 25 mm/day (1971-1990) to 17.2 mm/day (1992-2011) i.e., 32% reduction was noticed. A similar trend has also been noticed during recent years (1992-2011) for number of rainy days but it was very less i.e., only 6% for eastern U.P. The similar findings have also been reported by Tripathi *et al.*, 1998.

Table 4: Rainy days and rainfall intensity during south-west monsoon under different sectors of U.P.

Sectors	Rainy days of SWM (days)	Rainfall intensity of SWM (mm/day)
Eastern U.P.	48	17.2
Central U.P.	41	16.4
Western U.P.	45	15.6
Bundelkhand region of U.P.	40	15.4

Yield gap analysis of rainfed rice

Yield gap of rainfed rice in different sectors of U.P. has been shown in Fig. 3 to 6. It has been observed that the maximum yield gap was found in eastern U.P. (7.3 q/ha) at 865 mm rainfall followed by central U.P. (7.1 q/ha) at 780 mm rainfall and Bundelkhand region (5.9 q/ha) at 610 mm rainfall. In western U.P., the yield gap was lowest i.e., 3.9 q/ha only at 710 mm rainfall. Maximum yield gap was observed in eastern U.P. and minimum in western U.P. Minimum yield gap in western U.P. even at low rainfall (710 mm) shows the better

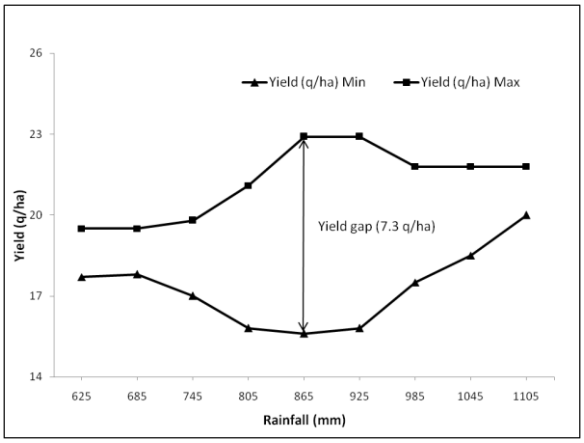

Fig. 3: Yield gap analysis of rainfed rice in western U.P under variable rainfall condition.

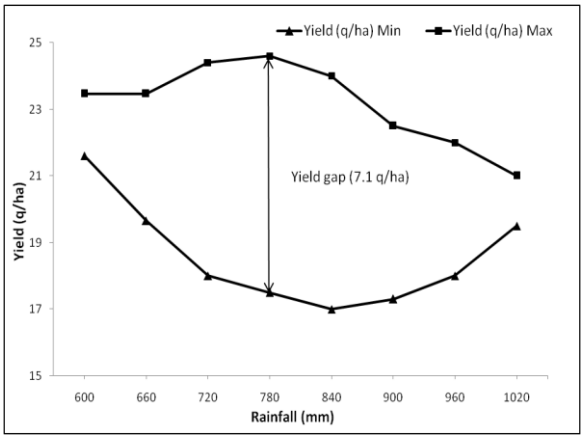

Fig. 4: Yield gap analysis of rainfed rice in Eastern U.P. under variable rainfall condition

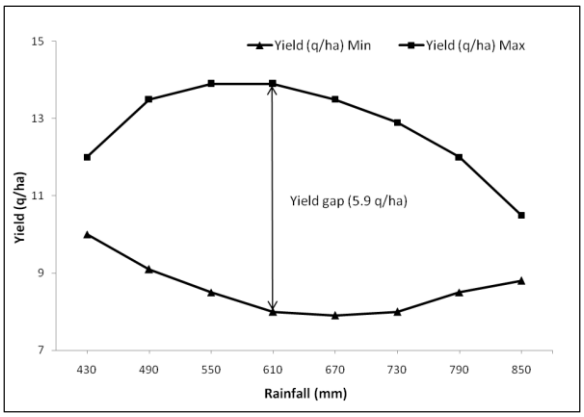

Fig. 5: Yield gap analysis of rainfed rice in central U.P. under variable rainfall condition

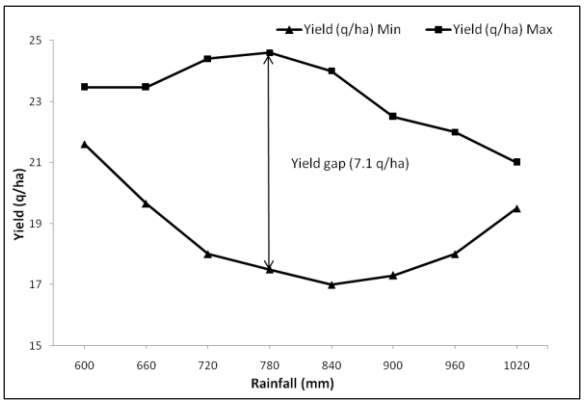

Fig. 6: Yield gap analysis of rainfed rice in Bundealkhand region under variable rainfall condition

management of rainfall i.e., low runoff, better utilization of water use efficiency whereas highest yield gap in eastern U.P. almost twice that of western U.P. at better rainfall availability (865 mm) indicate the need of more management care to minimize the yield losses hence yield gap. Central U.P. also needs similar type of management as that of eastern U.P. to minimize the yield gap. In Bundelkhand region of U.P., rice cultivation was not popular but now a days due to better rainfall availability orientation towards rainfed rice farming are increasing.

CONCLUSIONS

It was concluded that the quantum of total annual rainfall decreased in all sectors of U.P. with western U.P. at faster rate as compared to other sectors. Results of decrease of seasonal rainfall in different sectors were also in same order and magnitude as that of total rainfall. It may also be concluded from study that the total rainfall in relation to shift of onset of monsoon towards rainy season. The amount of rainfall decreased by 9.5 percent if onset of monsoon shift from 15th June to 25th June, hence crop planning is required accordingly. Length of rainy season was also reduced from normal 108 days to 99 days in U.P. therefore crop planning to short duration and low water requiring variety of rice in U.P./sectors of U.P. needs to be developed. The production/productivity constraints of rice through estimation of yield gap vis-à-vis climatic constraints for different sectors of U.P. was identified and concluded accordingly. This study will provide render help not only to the farmers for selection of crop, cropping pattern and change required in ongoing farming operations but also help to open an option window to select the crop/variety to grow in different sectors of U.P.

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International Journal on Environmental Sciences **6** (2) : 311-315, July-December 2015 **Research Article**
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Utilization of Whey in the Preparation of Whey – Shank Soup Thickened with Wheat Flour

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ABSTRACT

Whey has a Biological Oxygen Demand (BOD) of 38,000 to 46,000 ppm, even in some cases it reaches up to 76000 ppm as compared to 200 ppm permissible limit for domestic sewage. Non utilization of meat industry by-products (poultry shanks) causes major aesthetic and public health problems. Utilization of these by-products in the preparation of nutritious soup would solve major environmental pollution as well as provide nutritive beverage to consumers. Many starches such as corn gluten, waxy maize, potato starch, hydrocolloids like amylose, amylo pectin are used as thickeners to provide a desirable body, flavour, viscosity and nutritive value to soup. Therefore, an attempt was made to prepare the whey – shank soup utilizing both whey and poultry shank employing wheat flour (Maida) as thickener @ 0, 2, 4 and 6 % w/v of whey - shank extract. The common ingredients used for soup are spice mix, condiments, common salt and monosodium glutamate. The mixture was cooked over the flame along with thickener for 1.5 to 2 minutes. Increased concentration of wheat flour linearly increased the content of total solids, protein, ether extract and consistency of soup, whereas decreased the lactose content and meat flavor intensity of soup. The pH, content of protein and ash of soup non significantly changed. The shank-whey soup incorporated with 2% (w/v) wheat flour found good and scored highest for most of the sensory attributes particularly consistency when compared to control

Key words: Soup, thickener, whey, physico-chemical, sensory properties.

INTRODUCTION

Whey is a valuable by-product obtained during manufacture of cheese, chhana, paneer, casein etc. is usually discarded is increasingly frowned upon by environmentalists (Jindal *et al.*, 2004). The nutrients of whey have an indispensable value in human dietary requirement (Mathur *et al.*, 1988). India contributes approximately 8 million tones of whey production, has a Biological Oxygen Demand (BOD) of 38,000 to 46,000 ppm, even in some cases it reaches up to 76000 ppm as compared to 200 ppm permissible limit for domestic sewage (Mishra, 2008). Such Disposal of as raw whey causes serious problems of environmental pollution due to high organic matter content. Environmental Protection Act-1986, makes it obligatory to pre treat whey before discharge in inland water or rivers (Singh and Singh, 2012). Non utilization of meat industry by-products (poultry shanks) causes major

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aesthetic and public health problems (Ockerman and Hansen, 1988). Utilization of these by-products in the preparation of nutritious soup would solve major environmental pollution as well as provide nutritive beverage to consumers. Soup is a liquid food made by cooking vegetable, meat etc. together in a stock or water. Meat and bone broth have been used extensively in the preparation of soups. Soup made from skimmed bone broth is considered as an important convalescent food. Chicken meat is widely used for making a variety of soups such as chicken corn soup, yang soup, chicken peanut soup etc. The thickeners used in soup would provide the desired consistency/viscosity along with improved nutritive value to soup. Ruales *et al.* (1988) described the use of maize starch in dry soup mixes. Optionally modified maize starch can be used as a thickener in many foods including tomato sauce and cherry pie filling (Wurzburg and Fergason, 1984). According to Andon (1987), soup containing 4% starch did not provide any fiber, however, reduces the salt content to 2%. Various types of hydrocolloids are used as gelling or thickening agents in food industry like algae extract (agar agar, carrageenan, furcellaran, alginic acid, alginates etc.), plant extracts (pectin, pectic salts etc.), seed meals (guar, carob, tara etc.), plant exudates (Gummi arabicum, tragacanth, karaya etc), cellulose and cellulose derivatives, starch and starch derivatives, xanthan, gellan, gelatin, milk proteins etc. (Niederbaumer, 1994). Tapioca, potato, corn, mungbean, waxy maize, wheat, sweet potato and modified potato starches are used as thickening agents for Chinese cuisine sauces such as fish-smelling, szechwang and curry (Jong-Jang-Huang *et al.*, 1992). Toasted wheat is commonly used as thickener in sauces, soups and gravies in the form of flour.

MATERIALS AND METHODS

a) Raw materials: Fresh whey, shanks and other ingredients viz. spice mix, condiment mixture, common salt, monosodium glutamate were procured from RS Pura market, Jammu.

b) Methods: Properly descaled, chopped shank pieces (approx. 2 cm length) were pressure cooked along with whey at 1:4 ratios at 15 psi pressure for 30min. followed by filtration to get whey - shank extract. The extract was mixed conventionally with other ingredients viz. spice mix, condiment mixture, common salt, monosodium glutamate (MSG) @ 0.2%, 2.0, 1.0, and 0.1% w/v of bone extract respectively and then simmered in a stainless steel container for 1.5 to 2 min. to get the whey – shank soup (control, C). The extract was additionally thickened with wheat flour at 2(T1), 4(T2) and 6(T3) % w/v level before cooking. All soup samples are subjected to physico-chemical and sensory properties.

c) Evaluation Technique: The whey – shank soup was analyzed for protein, total solids, fat and ash (AOAC, 1995), titratable acidity (IS: SP: 18, 1981) and lactose (IS: 1479, 1961). The pH of soup was measured using electronic digital pH meter (Model: L1-120, ELICO Pvt. Ltd., Hyderabad). Sensory evaluation was performed based on 7-point hedonic scale. Wherein 7 denoted extremely desirable" and 1 denoted "extremely undesirable" (Keeton, 1983).The statistical design of this study was 4 (treatments) x 3 (replications). The data were analyzed on computer using statistical software packages developed by following the procedures of Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

The mean ± SE values for various physico-chemical parameters and sensory attributes of whey - shank soup are presented in Table 1. Incorporation of wheat flour as thickener non-significantly affected the pH, protein and ash content of whey – shank soup. Wheat flour (Maida) as thickener linearly increased the content of total solids and ether extract in whey –

shank soup. Whey-shank soup thickened with wheat flour at 4% w/v level contained significantly (P<0.05) higher titratable acidity. The content of lactose decreased and total solid and ether extract content increased as the level of thickener increased and the significance (P<0.05) difference was between control and treated products. Lachhiramani (1979) reported that a nutritive soup rich in minerals could be prepared by utilizing chicken shanks along with spices and water. Sam-gye-tang, a chicken based soup when cooked in a pressure cooker showed increase in calcium, potassium, magnesium and zinc, the contents of which increased with increase in cooking time (Sewon-Park *et.al.*, 1993). Sharma *et al.* (1990) observed that pressure cooking released greater amount of neutral lipids, but lesser amount of saturated fatty acids from marrow into soup when compared to cooking method of simmering in open kettle.

Incorporation of wheat flour significantly (P<0.05) increased the consistency of soup compared to control. The flavor and meat flavor intensity of soup non significantly decreased the as the level of thickener increased, However, the score for sensory attributes are within the acceptable range. Lesser concentration of meat extract in soup could be the possible reason for such phenomenon (Chidanandaiah, 1999). The increasing level of wheat flour as thickener decreased the overall acceptability at above 2% level. According to Lacchiramani (1979), chicken soups prepared by using chicken shank in water by pressure cooking method was rich in taste and flavours. Procedures for making chicken stock or soup by cooking chicken meat in water along with other necessary ingredients are available in literature (Shumakov *et al.*, 1982; Sewon-Park *et al.*, 1993). It could be concluded that the shank-whey soup with acceptable quality can be

Table 1: Effect of wheat flour as thickener on physico-chemical properties and sensory attributes of whey – shank soup*

Parameters	**Treatments**			
Physico-chemical	**C**	**T1**	**T2**	**T3**
pH	5.49 ± 0.07	5.49 ± 0.05	5.49 ± 0.07	5.41 ± 0.09
Titrable acidity	0.09^{a} ± 0.02	0.11^{ab} ± 0.01	0.13^{b} ± 0.01	0.12^{ab} ± 0.02
Lactose	6.66^{a} ± 0.04	6.58^{a} ± 0.08	6.38^{b} ± 0.14	6.33^{b} ± 0.14
Total solid	7.18^{a} ± 0.59	8.91^{b} ± 0.50	10.42^{c} ± 0.49	11.05^{c} ± 0.43
Protein	2.41 ± 0.09	2.53 ± 0.05	2.56 ± 0.07	2.57 ± 0.08
Ash	1.15 ± 0.01	1.18 ± 0.01	1.18 ± 0.03	1.18 ± 0.04
Ether extract	0.58^{a} ± 0.03	0.38^{b} ± 0.04	0.40^{b} ± 0.07	0.43^{b} ± 0.09
Sensory attributes				
Colour & appearance	7.00 ± 0.14	7.00 ± 0.14	6.85 ± 0.17	6.75 ± 0.14
Flavour	6.55 ± 0.14	6.50 ± 0.09	6.50 ± 0.22	6.50 ± 0.20
Consistency	5.00^{a} ± 0.24	5.50^{ab} ± 0.12	6.00^{ab} ± 0.19	6.50^{b} ± 0.19
Meat flavor intensity	6.50 ± 0.18	6.50 ± 0.18	6.25 ± 0.20	6.25 ± 0.16
Overall acceptability	7.00 ± 0.21	7.00 ± 0.16	6.75 ± 0.20	6.50 ± 0.19

Note: *Means with different superscripts (alphabets) row-wise differ significantly (P<0.05)
C- control, without thickener, T1:2% wheat flour incorporation,
T2: 4% wheat flour incorporation, T3: 6% wheat flour incorporation

prepared by incorporation of wheat flour (maida) as thickener @ 2% (w/v) whey – shank extract.

CONCLUSION

Whey and poultry shanks can be effectively utilized in the preparation of nutritious whey – shank soup would reduce major environmental pollution as well as provides nutritive beverage to consumers. The whey – shank soup with acceptable quality can be prepared by incorporation of wheat flour (maida) as thickener @ 2% (w/v) whey – shank extract.

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Status of Air Quality Index near Industrial Belt of Meramandali Area in Dhenkanal District, India

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ABSTRACT

The present investigation was carried out to significant of air pollutant concentrations at up coming industrial area of Dhenkanal District of, Odisha, India, an emerging steel and power hub in this district. PM2.5, PM10, sulphur dioxide (SO2) and oxides of nitrogen (NOX) date were collected over eight stations near Meramadali area of Dhenkanal District FY 2012-13 of summer and winter sessions.

The annual average and range values with AQI have also been calculated and computed. It has been observed that the concentrations of the pollutants are high in winter in comparison to the summer or the monsoon and post monsoon seasons. In the present study, it was noticed that the PM2.5 and PM10 levels at all selected sites exceeds the prescribed limits as stipulated by Central Pollution Control Board (CPCB) New Delhi. Apart from this the SO2 and NOX levels in industrial areas remain under prescribed limits of CPCB. The AQI also computed in both the session and found four locations severe air pollution and four locations moderate air pollution during summer and all stations in winter observed severe winter pollution.

Key words: Air quality index, PM2.5 particles, PM10 particles, air pollution, industries, sampling stations.

INTRODUCTION

Air is one of the five vital basic natural ingredients of life system. The mmediate environment of human-being comprises of air on which depends all forms of life. The major anthropogenic sources of air pollutants are industrial emissions, domestic fuel burning, emissions from power plants and transportation activities etc. The advent of technological and scientific innovations in various fields and diverse activities of human race for its sophistication have put extra load on the tmosphere by way of releasing air pollutants like suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), sulphur dioxide (SO2), oxides of nitrogen (NOx), carbon monoxide (CO), unburned hydrocarbon (HC), hydrogen fluoride (HF) and other organic as well as inorganic pollutants including trace metals responsible for causing health consequences.

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Air Pollution indeed is now a serious worldwide public health problem. The short term health impacts of air pollution have been studied extensively since the London fog in the mid 20th Century and subsequent series of dreaded incidents in industrialized countries. The compatibility between ecology and economy is one of the most burning issues of the present times. Developmental activities e.g. industrial expansion, mining exploration, transportation and constructional works etc. cause degradation and drastic changes in every component of environment namely; hydrosphere, lithosphere, atmosphere and biosphere through pollution. Air pollution has emerged in the past few decades as the most crucial problem to the mankind and a large number of studies in this regard have been undertaken in all over the World (Katsouyanni et al., 2001: Afroz et al., 2003: Yang et al., 2004: Samoli et al., 2005: Analitis et al., 2006: Kaushik et al., 2006: Barman et al., 2010, Panda and Panda,2012).

Fig. 1: The Location map of the study area.

MATERIAL AND METHODS

Since, the city is growing very rapidly with industrial projects and population, it is necessary to check air quality at regular intervals.

Study Sites

The total eight sampling monitoring sites were selected in the study area of meramandali location belongs to Dhenkanal District. The present stations were monitored for the year 2012-13.

February, 2013. The study was carried out by means of sensitive diffusion samples in ambient air during the period March, 2012 to February, 2013 (Summer to Monsoon). Total eight(8) sampling stations were exposed during the period for monitoring of PM2.5, PM10, SO2, NOX and meteorology data.The present study deals with the effect of industrialization emission on ambient air quality near meramandali area of Dhenkanal District.

Methodology

Air pollutants (SO2, NOX, PM2.5 and PM10) monitoring data for site was measured with the help of RDS APM 460 NL by sucking air into appropriate reagent for 24 hours at every six months of two seasons for the year 2012-13 from 8 locations and after air monitoring it procured into lab and analysis for the concentration level. . The apparatus was kept at a height of 2 meters from the surface of the ground. The PM2.5 and PM10 were analyzed using Respirable Dust Sampler (RDS) APM 460 and operated at an average flow rate of 1.0-1.5 m3 min-1. Preweighed glass fiber filters (GF/A 20.3x25.4 cm) of what man were used as per standard methods.

SO2 and NOX were collected by bubbling the sample in a specific absorbing (sodium tetrachloromercuate of SO2 and sodium hydroxide for NOX) solution at an average flow rate of 0.2-0.5 min1. The impinger samples were put in ice boxes immediately after sampling and transferred to a refrigerator until analyzed. The concentration of NOX was measured with

standard method of Modified Jacobs - Hochheiser method. SO2 was measured by Modified West and Geake method, PM2.5 and PM10 using filter paper methods.

Air Quality Index (AQI)

The Air Quality Index (AQI) is an environmental index which describes the overall ambient air status and trend of a particular place based on specific standard. It is a tool that transforms the (weighted) values of individual air pollutants (parameters) into a single number or set of numbers (Rao, 1993). The overall ambient air quality of a specified area can be assessed in a better way and quantified in terms of AQI since it represents the cumulative effect of all the pollutants. AQI can also enable one to formulate the alternative policies for prevention of air pollution or to design control equipment which, for instance, will reduce the level of certain pollutants while increasing the levels of others. There are several methods and equations used for determining the AQI. However, here the below mentioned equation (Zlauddin and Siddiqui, 2006: Joshi and Semwal, 2011) has been used for computation of AQI value.

AQI = ¼ x (ISPM / SSPM + IRSPM / SRSPM + ISO2 / SSO2 + INOx / SNOx) x 100

Where ISPM, IRSPM, ISO2 and INOx = Individual values of suspended particulate matter, respirable particulate matter, sulphur dioxide and oxides of nitrogen respectively obtained on sampling.

SSPM, SRSPM, SSO2 and SNOx = standards of ambient air quality as prescribed by the Central Pollution Control Board of India (CPCB).

The higher the AQI value, greater is the level of air pollution and greater is the health risk. The AQI scale is divided into five categories as depicted in Table -3 . It describes the range of air quality and its associated potential health effect.

RESULTS AND DISCUSSIONS

The present study deals with the air pollutants concentrations and air quality index (AQI) at eight monitoring sites of meramnadali area of Dhenkanal District.

Table–1 represents the average characterization of eight selected monitoring sites of ambient air quality parameters with AQI of summer season and Table-2 represents the average characterization of eight selected monitoring sites of ambient air quality parameters with AQI of winter season .

Site–Specific seasonal Variations

In FY 2012-13 table 1 and 2 depicted that the maximum Pm10 value was 297±35 at narendrapur and minimum was 123±21 at Khaliberana during summer. The maximum Pm10 value at Nuahata was 296±42 and minimum value was 139 ±21 at Motanga during winter. The maximum Pm2.5 value was 157±21 at Narendrapur and minimum was 53±12 at khaliberana during summer. The maximum value of Pm2.5 was 159±19 at near Narendrapur and minimum was 66 66±32 at Galapoda during winter.

The maximum SO2 concentration was 18.8±3 at Nuahata and minimum was 4±1 at Motanga during summer. The maximum SO2 concentration was 18.13±3 at Nuahata and minimum was 4±1 at galpada during winter.

The maximum NO2 concentration was 41.1±8 at Nuahata and minimum was 11.1±4 at Narendrapur during summer. The maximum NO2 concentration was 40.3±7 at Nuahata and minimum was 11.5±1 at Narendrapur during winter.

Air Quality Index

The average AQI for different stations are depicted in table-4(a),Fig.1 and 4(b) ,Fig-2of summer and winter seasons. The highest AQI 125.90 µg/m3 (severe air pollution) at Nuahata

and lowest 81.83 µg/m3 (Moderate Air Pollution) at Khaliberana were observed in Sampling station during Summer session of study period. Similarly the highest AQI 156.25 µg/m3 (Severe Air Pollution) at Near BSL gate and lowest 118.25 µg/m3 (Severe Air Pollution) at Nalatangara were observed in Sampling stations during winter session of study period. However in winter session all locations showing severe Air Pollution.

Table 1: Average value of Ambient Air Quality parameters (Summer). (Period: 2012-13)

Permissible AAQ standard	**Results in µg/m3**											
	PM10			**PM2.5**			**SO2**			**NO2**		
Industrial/Rural and other area(24 hrs)	**100**			**60**			**80**			**80**		
Ecological Sensitive area (notified by Central Gov.) Residential (24 hrs)	**100**			**60**			**80**			**80**		
MonitoringLocation	Min.	Max.	Arth. Mean	Min.	Max.	Arth. Mean	Min.	Max	Arth. Mean	Min.	Max.	Arth. Mean
Motanga	140±23	255±24	214±22	82±12	118±25	96±12	4±1	13.7±4	8.2±2	20.7±2	38.7±9	30.1±5
Galpoda	150±40	263±41	204±35	62±21	114±40	92±13	4±2	13.7±5	5.5±2	12.6±3	27.4±8	18.6±5
Nalatangra	161±20	238±23	199±18	79±23	100±14	88±15	4±1	12.9±2	5.9±1	12.6±4	32.7±6	19.5±4
Nuahata	182±23	292±25	247±24	96±21	133±13	117±14	4±1	18.8±3	8.2±2	19.3±3	41‘.1±8	27.6±4
Near BSL gate	171±34	297±35	243±32	84±12	157±21	126±13	4±2	15.1±3	7.4±2	11.1±4	34.4±5	20.4±3
Gopalpur	169±21	279±23	203±22	75±13	115±12	91±12	4±1	17.2±4	8.1±2	15.1±3	39.5±7	25.7±4
Birbhaanpur	158±22	240±24	193±23	57±13	134±14	85±16	4±1	10.2±5	5.1±3	12.9±4	27.1±3	18.5±3
Khaliberana	123±21	239±25	162±23	53±12	118±25	83±13	4±1	16.9±3	5.4±2	11.1±5	21.7±5	16.2±4

Table 2: Average value of Ambient Air Quality parameters (Summer). (Period: 2012-13)

Permissible AAQ standard	**Results in µg/m3**											
	PM10			**PM2.5**			**SO2**			**NO2**		
Industrial/Rural and other area(24 hrs)	**100**			**60**			**80**			**80**		
Ecological Sensitive area (notified by Central Gov.) Residential (24 hrs)	**100**			**60**			**80**			**80**		
Monitoring Location	Min.	Max.	Arth. Mean	Min.	Max.	Arth. Mean	Min.	Max	Arth. Mean	Min.	Max.	Arth. Mean
Motanga	139±21	250±41	214±35	82±11	124±16	96±18	4±1	13.9±4	8.3±2	20.6±2	38.9±9	30.1±5
Galpoda	151±23	264±38	204±25	66±32	119±28	93±19	5±1	13.6±5	5.9±1	12.9±3	27.4±5	18.5±4
Nalatangra	163±22	242±39	199±23	79±26	106±23	88±26	4±2	12.6±3	5.9±2	12.5±3	32.9±8	19.5±6
Nuahata	185±38	296±42	247±35	91±26	135±29	117±31	4±2	18.13±6	8.2±2	19.8±2	40.3±7	27.6±4
Near BSL gate	177±37	298±43	243±35	86±25	159±19	126±29	4±2	15.14±4	7.4±1	11.5±1	35.6±5	20.4±3
Gopalpur	172±36	278±41	203±24	78±19	117±14	91±26	4±1	17.21±6	8.1±1	15.4±2	39.65±7	25.7±5
Birbhaanpur	159±35	246±34	193±23	59±18	136±35	85±19	3±1	10.29±5	5.1±2	12.4±2	27.9±8	18.5±4
Khaliberana	75±15	241±34	162±26	75±11	119±29	83±14	4±1	16.94±3	5.4±1	11.9±3	21.93±5	16.2±3

Table : 3 Rating Scale of Air Quality Index.

AQI Value	Remarks	Health Concern
00-25	Clean air(CA)	None/minimal health effect
26-50	Light air pollution(LAP)	Possible respiratory or, cardiac effect for most sensitive group
51-75	Moderate Air Pollution(MAP)	Increasing symptoms of respiratory and cardiovascular illness
76-100	Heavy Air Pollution(HAP)	Aggravation of heart and lung diseases
>100	Severe Air Pollution(SAP)	Serious aggravation of heart and lung diseases Risk of death in children.

Table 4 (a) : The Average Value(in μg/m3) of air pollution and Air Quality Index for different locations of Summer Session.

Locations	Pm10	Pm2.5	So2	Nox	AQI	Remarks
Motanga	214	118	13.7	38.7	105.46	Severe Air Pollution
Galpoda	204	114	13.7	27.4	102.17	Severe Air Pollution
Nalatangara	199	100	12.9	32.7	98.47	Heavy Air Pollution
Nuahata	247	133	18.8	41.1	125.906	Severe Air Pollution
Near BSL Main Gate	243	157	15.1	34.4	121.93	Severe Air Pollution
Gopalpur	203	115	17.2	39.5	99.22	Heavy Air Pollution
Birbahanpur	193	134	10.2	27.1	91.04	Heavy Air Pollution
Khaliberana	162	118	16.9	21.7	81.83	Heavy Air Pollution

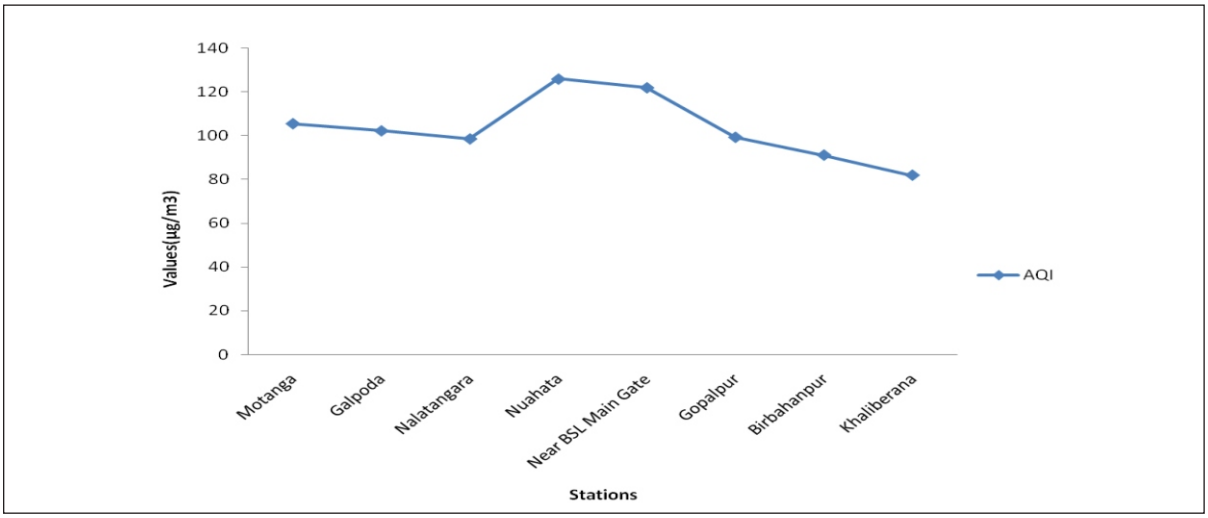

Fig. 2: Stations wise AQI Values during summer sessions.

Table 4 (b) : The Average Value(in μg/m3) of air pollution and Air Quality Index for different locations of Winter Session.

Locations	Pm10	Pm2.5	So2	Nox	AQI	Remarks
Motanga	250	124	13.9	38.9	130.25	Severe Air Pollution
Galpoda	264	119	13.6	27.4	127.25	Severe Air Pollution
Nalatangara	242	106	12.6	32.9	118.25	Severe Air Pollution
Nuahata	296	135	18.13	40.3	148.25	Severe Air Pollution
Near BSL Main Gate	298	159	15.14	35.6	156.25	Severe Air Pollution
Gopalpur	278	117	17.21	39.65	135.75	Severe Air Pollution
Birbahanpur	246	136	10.29	27.9	129.5	Severe Air Pollution
Khaliberana	241	119	16.94	21.93	121.75	Severe Air Pollution

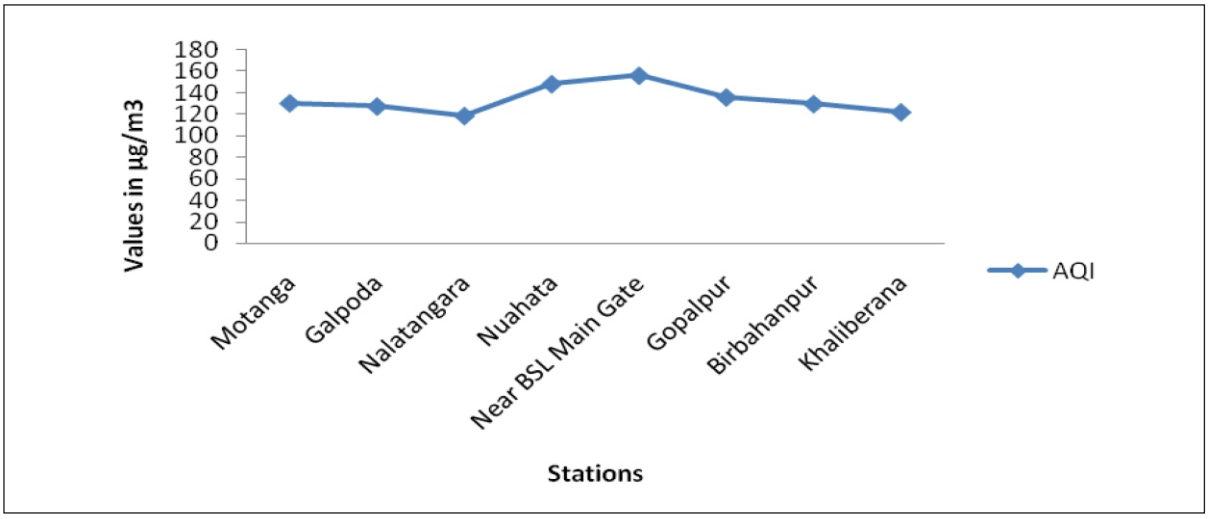

Fig. 3: Station wise AQI Values during Winter session.

CONCLUSIONS

The above findings were Computed and analyzed both the session air data revealed that Pm10 and Pm 2.5 were the major air pollutants at majority stations. However, gaseous pollutants (SO2 and NOx) were well within the permissible limit at all locations.

The study clearly indicated that it would be more appropriate to consider AQI rather than individual air pollutant level while planning prevention of air pollution in industrial areas. From AQI values, it was found that there was severe air pollution at four locations and heavy air pollution at four locations during summer session .

in Winter session at all locations severe air pollution observed.. It was also observed that particulate emission was an outside factory phenomenon and was basically transport related and levels were relatively high during winter in comparison to summer and monsoon.

To contain the Pm10 and Pm2.5 concentrations within an acceptable level, it is suggested that massive green plantation must be taken up in the entire area, trees having high dust trapping efficiency are to be grown alongside the roads and water is to be sprinkled continuously at the source of generation of particulate matter immediately.

These apart; measures like limiting vehicle speed at vulnerable localities, conducting public awareness campaigns about the harmful effect of air pollution and educating the drivers to be more eco-friendly; are also to be taken. Moreover, regulatory Authorities must ensure that industries discharge their moral and social responsibilities to protect the environment.

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Status and Ecology of Indian Sarus Crane, *Grus antigone antigone* in and around the Alwara Lake of District Kaushambi (U.P.)

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ABSTRACT

The sarus crane is well known for its ability to live in association with humans, inhabiting open, cultivated, well watered plains, marshlands and lakes. The best common site for sarus crane population growth is areas mixed with natural wetlands in the landscape and traditional major crop sites including paddy fields. These areas suit them for foraging, roosting and nesting. Sarus crane is an omnivorous bird. They feed in shallow water on marshes, berries, seeds, roots, tubers, invertebrates, butterflies, grasshoppers, insects, fishes, frogs, reptiles and eggs of birds. Sarus crane is the largest of the crane species found in India.

The sarus crane (*Grus antigone*) belongs to phylum: Chordata, class: Aves, order: Gruiformes and family: Gruidae. Present study is aimed to explore the ecology and status of the sarus crane in modern context in and around the Alwara lake of Kaushambi district of Uttar Pradesh. Present study will not only help to attract the biologists for detailed exploration of the said lake but also draw attention for making and implementing the effective strategy for the conservation of this crane.

Key words: Sarus crane, anthropogenic activities, vulnerable, conservation, Alwara lake.

INTRODUCTION

The Indian Sarus Crane *Grus antigone antigone* (Linnaeus, 1758) is the world's tallest flying bird (Archibald *et al.*, 2003) and is the only resident breeding crane in India (Mukherjee *et al.*, 2002). Its population is comparatively more in Uttar Pradesh than other states. It is the world's biggest flying water bird and is declared as State Bird by the Government of Uttar Pradesh for its conservation.

The name “Sarus” has its origin from Sanskrit word- 'sarasa', which means 'lake bird' and the dance of the sarus has undoubtedly led to the species getting the name. The skin of this bird was first studied and described by Carolus Linnaeus who named it as *antigone* in 1758. The term '*antigone*' refers to a female character in Greek philosophy, famous as a rebellious daughter of the King Oedipus. There was a myth that cranes pair for life and in the event of the death of one bird the other dies beside the dead body of its mate. This myth has been prevailing around for centuries and Linnaeus was aware of this aspect when he named the species.

The population density of sarus crane is

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inseparably associated with wetland habitats. Several investigators have tried to study different aspects of sarus crane (Sundar 2011; Sundar *et al.* 2012; Mukherjee *et al.* 2002; IUCN 2012; Clements *et al.* 2013).

The Indian sarus crane has been listed as globally threatened i.e. vulnerable avian species (Bird Life International 2012) because of its declining numbers. Reasons behind this decline include decline in habitat quality, exploitation, pollution, competitors, parasites etc. The increased anthropogenic activities, changed use of land and degradation of wetlands for agricultural expansion as well as for industrial development are the most serious threats to the cranes (Gole, 1989; Parasharya *et al.*, 1989). As a consequence, the species has suffered a rapid population decline within a few decades (Choudhary 1999).

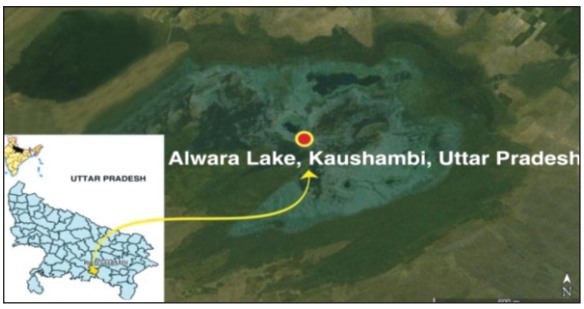

Image 1: The location of the study area.

Present study is therefore aimed to explore the ecology and status of this sarus crane in modern context in and around the Alwara lake of Kaushambi district of Uttar Pradesh.

STUDY AREA AND ITS CLIMATE

The lake under exploration is a natural lake and now a part of important perennial wetland. It is surrounded by agricultural fields and connected to the river Yamuna and covers about several hectares. In this lake, the water level falls during summer and winter but rises during rainy season. The lake has derived its name from village Alwara. Locally it is called Alwara Taal. The Alwara lake is surrounded by Paur Kashi Rampur in east, Tikara in the north, Shahpur in the south and the river Yamuna in the west.

The Alwara lake is located in Kaushambi district of Uttar Pradesh. The lake is 75 km away from Allahabad, 25 km from Manjhanpur (headquarter of district Kaushambi) and 290 km from Lucknow by road. Its nearest railway station is Bharwari at a distance of 35 km and nearest airport Bamrauli (Allahabad) is at a distance of 70 km. It is situated between the latitude 25°24'05.84"S – 25°25'10.63"N and longitude 81°11'39.49"E-81°12'57.95"W with altitude MSL – 81.08 meter.

Its weather is tropical to subtropical with some variations over the year. Winter season occurs between late October and February but mid December to mid January is the season of severe cold and irregular appearance of fogs. Spring season occurs usually from mid February to end of April. Summer season comes in the month of March and ends in late June. It is marked by high velocity winds including heatstroke. In local and vernacular language it is called *loo*, which is a strong, hot and dry summer afternoon wind from the west which blows over the western Indo-Gangetic plain region of North India. It is especially strong in the months of May and June. Rainy season starts from late June to early October. Approximately 350 mm rainfall observed annually but irregularity in rainfall is also noticed year wise which influences the landscape ecology of the lake. Autumn season commences in mid October and ends in late November. Temperature shows with high fluctuation over the year and noticed determinant parameters of this landscape.

Image 2: A view of Alwara lake.

MATERIALS AND METHODS

The authors used binocular, camera, motorbike, chappu boat, field stick etc. for various purposes. The findings are based upon the work conducted between January and December, 2013. Investigations were conducted in morning hours from 7.00 am to 9.00 am and evening hours from 3.00 pm to 5.00 pm during our routine field trips. All the observations were made while moving through the chappu boat and walking along the croplands, mud lands, natural areas using binoculars (7x35 and 8x40-BEZIF BM-9). Sights and calls were the devices to enlist a bird at a particular site.

Identification of different species was aided by using standard guides such as Ali (1941), Wild Life Institute of India wetland research methodology (1999) and Aryal *et al*, (2009). Besides actual sightings, inquiries from local people were also made to ensure the estimate of existing population and their perceptions about the existence of the crane. Census was avoided during rainy days as possible. Population comparison was determined as a single, pair, pair with one juvenile, pair with two juveniles and flocks comprising adults and juveniles.

RESULTS AND DISCUSSION

Sarus is a social bird and during study period they have been seen in pairs or with juvenile or in congregation (sometimes singly). The family group occurs in whole year but during non-breeding season, the congregation of sarus are reported up to 200 (Gole, 1991a) for mate finding or pair formation. These are involved in social displays to facilitate the pairing of unmated birds and to establish a pecking order among families. Male attracts the female to display dance like movement.

Image 3: Survey of lake by Chappu Boat.

Image 4: Sarus crane in solo (single).

Image 5: Sarus crane in pair.

Prakash *et al,* (2014) reported 487 cranes from September 2011 to December 2012 in three different transects of Alwara lake and argued that from ecological point of view this site is very favourable for sarus crane distribution. They reported 335 sarus cranes in and around the Alwara lake in 2012 but surprisingly present exploration and investigation collected a data of 425 cranes in the same study area during the period of 12 months in 2013. Such a large number is creating a positive hope that declining population of sarus crane will definitely increase. The reason behind the increase in population of this water bird is due to openness, suitable agricultural land and seasonal marshes dominated over the climatic factors and occurrence of favourable ecological, feeding, mating and nesting conditions as well.

Image 6: A view of Alwara lake showing endangered lotus

At the same time, authors found some endangered plant species also such as lotus. The lotus or Indian lotus or sacred lotus is a symbol of Indian cultural heritage, deeply associated with Hindu mythology, art and culture. The Indian lotus is the National Flower of India.

CONCLUSIONS

In general, the sarus cranes are at the verge of extinction globally due to widespread reductions in the extent and quality of their wetland habitats, exploitation and the effects of pollutants, unplanned farming, irrigation and non-adoption of wild life rules and regulations as well. The main challenge is to maintain their original or unaltered natural habitat as a result of one or more anthropogenic activities including pollution, agricultural expansion, use of pesticides, removal of soil for various purposes, removal of vegetation, land encroachment, fishing and unplanned development. Due to its declining number, Indian sarus crane has been now listed as globally threatened i.e. vulnerable avian species (Bird Life International 2012).

In contrary, the number of sarus crane is found increased in and around the Alwara lake during the period of 12 months in 2013 as compared to 2012. Such a large number is not only creating a positive sign that declining population of sarus crane will definitely increase but also important for ecological balance. This is happening only because of favourable environmental conditions for sarus crane in and around the Alwara lake.

As such the authors have initiated a public awareness campaign through farmers to save this species from becoming extinct and recommend the declaration of the entire lake zone as a conservation area through applicable and effective policy. There should be a protection of wetlands to provide additional habitat for sarus cranes by controlling sedimentation of the wetlands. Sundar (2006, 2011), Clements *et al.* (2013) have conducted detailed studies on this threatened species and proposed direct reward for the protection of biodiversity as an effective tool for delivering conservation outcomes in a way that also delivers developmental benefits to the local people.

The authors recommend continuous population census of this species and declaration of the entire Alwara lake region as a "**Sarus Safe Zone**" for the conservation of sarus crane with regular monitoring. Measures should be taken to minimize the huge exploitation of natural resources of the Alwara lake.

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International Journal on Environmental Sciences **6** (2) : 328-334, July-December 2015 **Research Article**
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Study on the Seasonal Variation in Malcofaunal Diversity of Budhi Gandak River and Muktapur Maun, near Samastipur District, Bihar

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ABSTRACT

Lotic systems, such as rivers, streams and creeks account for the largest and most ecologically diverse freshwater ecosystems in the earth. Despite their importance, these ecosystems are rapidly being modified or destroyed. River Budhi Gandak is the major lotic system of state Bihar, which is well known for its meandering nature. There is a possibility of origin of Muktapur maun of Samastipur District by river Budhi Gandak. There is a burning need for monitoring the status and trends of freshwater biodiversity in order to quantify the impacts of human actions on freshwater systems and to improve freshwater biodiversity conservation. Present study, haulage the assessment of freshwater biodiversity, focused mainly on the groups of mollusc, or identify keystone species for conservation purposes. During last decades due to several anthropogenic activities these water bodies drastically changed or modified. In this context, present study carried out to study the Malcofaunal diversity of river Budhi Gandak and Muktapur maun. Altogether, 17 species of aquatic molluscs were recorded belonging to 9 genera and 7 Families. These molluscs include 13 species of Gastropods and 4 species of Bivalvia. Family Viviparidae was most dominated family in gastropods followed by Lymnaediae, whereas, in Pelcypoda, family Unionidae was most dominated. During current study, it was also observed that, the molluscan diversity is seriously affected or under stress condition due to pollutants and needs some conservation measure.

Key words: Budhi Gandak river, Muktapur maun, Gastorpod, Bivalve, Molluscan diversity.

INTRODUCTION

Water is of great importance in the development of civilization, global hydrological cycle and for the supply of water to humankind. Witness for example, that all major civilizations have evolved in association with aquatic systems, as confirmed today by the location of foremost cities. Globally, freshwater has become the fastest depleting natural resource. The toxic chemicals from industries, agricultural run-off of pollutants and chemicals, human wastes and sewage etc affect the natural rhythm of the system, by affecting species interactions. The increasing human influences in recent years in and around our aquatic systems and their catchment areas, have led to the deterioration of water quality and eutrophication. Life in aquatic environment is largely governed by quality of any water body.

Among various hydrobiont groups, benthic invertebrates are particularly attractive research objects, because their life cycles are short and

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they also easily adapt the environmental conditions. High abundance of benthic macro invertebrates allows using them as indicator organisms in the monitoring of aquatic ecosystem quality (Obolewski and Lewczuk, 2011).

Molluscs are some of the most ancient animals that inhabits on/in the benthic environment of the aquatic environment and terrestrial environment. Their appearance in prehistoric deposits dates from 500 million years ago. During this historical period, molluscs have undergone waves of extinctions; however, today the rate of extinction affecting freshwater molluscs is much faster than previously experienced. The main reasons for this rapid extinction rate is that molluscs are extremely vulnerable to habitat degradation pollution, over-exploitation, and predation by alien species. Instead of freshwater molluscs, marine molluscs have received more attention because of their aesthetic and gastronomic appeal. Freshwater molluscs are an integral part of the rich invertebrate phylum mollusca. They found all over the world except for Polar Regions, high altitudes and some remote islands. There are around 6,000 known species of gastropods and bivalves that live in freshwater habitats. Freshwater bivalves include animals such as clams and mussels, while freshwater gastropods include snails and slugs. There are list of work carried out on the river Budhi Gandak. In this context present work has undertaken to observe that what are species present in the river Budhi Gandak and Muktapur maun during different seasons.

MATERIALS AND METHODS

Study area

The river Budhi Gandak major lotic system of state Bihar, originates from Chautarwa Chaur near Bisambharpur in the district of West Champaran in Bihar and flows through the districts of East Champaran, Muzaffarpur, Samastipur and Begusarai. It outfalls into the Ganga near Khagaria. The current studies were conducted near Samastipur town. The river Budhi Gandak is well known for its meandering nature. There is a possibility of origin of Muktapur maun of Samastipur District by river Budhi Gandak. Muktapur oxbow lake or maun is located about 5 km away from Samastipur railway station and 6 km North of Samastipur town in the Samastipur district of Bihar. The principal features of the maun are horse shoe shaped, depth varies between 3 and 6m and an area 60 hectare. One of arms of the maun receives jute mill wastes occasionally.

Methodology

The molluscs of river Budhi Gandak and Muktapur maun were studied during January, 2011 to December, 2012. In Budhi Gandak River five sampling sites and Muktapur maun three sampling sites were selected. For collection of molluscs a unit corer with 10cm height and 8cm radius was inserted 5 to 6 spots at each field station. Polythene bags were used to carry samples to laboratory where samples were sieved (mesh size 2 mm). Molluscs were picked up with the help of forceps. The collected molluscs were preserved separately in 4% formalin. For identification of molluscs standard keys given by Rao (1989) were used. For quantitative analysis, numbers of picked living snails were counted quadrate wise and also species wise and then average of this was considered as a unit for the site per visit. The data of the two consecutive years study (from January, 2011 to December, 2012) was pooled for three months and four seasons and analyzed for seasonal variations, with respect to winter (January, February, March), summer (April, May, June), Monsoon (July, August, September) and Post monsoon (October, November, December). Populations per m^2 were calculated by using formula described by Saxena (2001):

Molluscs No/m^2 = (N/A) x 10^4

Where,
N= Number of gastropods per sample
A= Area of sampler (cm^2)

RESULTS

During present study, the total 17 species of aquatic molluscs were recorded belonging to 9 genera and 7 Families. These molluscs include 13 species of Gastropods and 4 species of Bivalvia. During present study, the result obtained in both the aquatic habitats were depicted in Table 1 and 3. Taxonomic description of species is depicted in Table 2. The average value of all the sampling stations were incorporated and found the positive correlation in both the aquatic ecosystems the correlation value being 0.978457. During present study, it was observed that in both the aquatic habitats minimal density was observed during summer season and maximum during post monsoon season (Fig. 1). Comparatively it was observed that river Budhi Gandak having more species richness in relation to Muktapur maun. During current study, family Viviparidae was most dominated family in gastropods followed by Lymnaediae, whereas, in Pelcypoda, family Unionidae was most dominated contributing four species each.

Table 1: Seasonal variation in molluscan density.

Seasons	Budhi Gandak river(No./CuM)	Muktapur maun (No./CuM)
Winter-1st yr	48	32
Summer	46	27
Monsoon	61	52
Postmonsoon	104	85
Winter-2nd yr	52	34
Summer	48	28
Monsoon	63	48
Postmonsoon	112	82

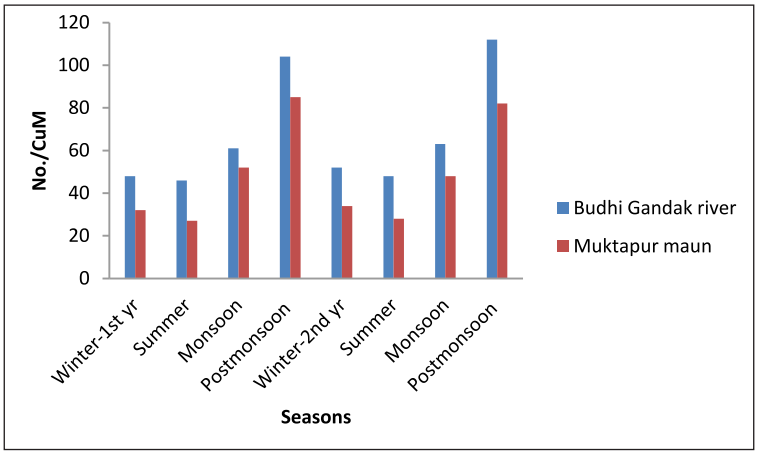

Fig.1: Showing the seasonal variation in molluscan density in Budhi Gandak river and Muktapur maun.

Table 2: Taxonomic description of molluscan species.

Phylum	Class	Order	Family	Species
Mollusca	Gastropoda	Mesogastropoda	Viviparidae	*Bellamya mandiensis*
				Bellamya bengalensis
				Bellamya variata
				Bellamya eburnea
			Melonidae	*Melanoides tuberculata*
			Thiaridae	*Melania tuberculata*
				Tabereia granifera
		Basommatophora	Lymnaeidae	*Lymanea acuminata*
				Lymanea rufencence
				Lymnea luteola
			Pilidae	*Pila globosa*
				Pila virens
			Planorbidae	*Indoplanorbis exustus*
	Pelcypoda	Eulamellbrachiata	Unionidae	*Lamellidens marginalis*
				Lamellidens corrianus
				Parreysia corugata
				Parreysia favidins

Table 3: Showing the species richness in both the aquatic habitat.

Species	Muktapur maun	Budhi Gandak river
Bellamya mandiensis	++	+++
Bellamya bengalensis	++	+++
Bellamya variata	+	+++
Bellamya eburnea	+	+++
Melanoides tuberculata	++	++
Melania tuberculata	—	+++
Tabereia granifera	—	+++
Lymanea acuminata	+++	+
Lymanea rufencence	++	++
Lymnea luteola	-	+++
Pila globosa	+++	+++
Pila virens	+	++
Indoplanorbis exustus	++	+++
Lamellidens marginalis	—	+++
Lamellidens corrianus	—	+++
Parreysia corugata	—	++
Parreysia favidins	—	++

+List, ++ Abundant, +++ More Abundant, — absent

DISCUSSION

Molluscan are considered as the most diverse and dominant benthic fauna both from lentic and lotic region which are mainly represented by the two major classes namely Gastropods and Pelecypods (Mackie, 1998). Patil and Talmale (2005) published the checklist of the land and fresh water molluscan of Maharashtra state where they had reported 142 species of molluscan of all forms belonging to 42 genera including 23 families whereas during present study, the total 17 no. of species of aquatic molluscs recorded belongs to 9 genera and 7 Families. Prabhakar and Roy (2008) have observed 18 Gastropod species and 7 Pelecypod species from north Bihar region of India whereas during present study, only 13 species of Gastropoda and 4 species of Bivalvia were found from both the aquatic habitats. Waghmare *et al.* (2012) reported only 15 species from a polluted river (Bhima river) from maharastra, India.

During current study, 14 species of gastropod belonging to three orders were recorded from both the ecosystem. High molluscan diversity in River Barak and its tributaries in Assam were reported and it was observed that gastropods were in dominant position than bivalves and recorded sixteen molluscan taxa belonging to two order (Roy and Gupta, 2010). Among the gastropods, family Viviparidae was most dominated family in gastropods followed by Lymnaeidae where as Choubisa and Sheikh (2013) reported that during their study Lymnaeidae where most dominated family. During current study, it was observed that different species of same genus occupied diverse niche, such as *Lymnaea acuminata* species inhabited mostly lentic habitats where as *L. luteola* was found to be restricted only to lotic waters (Choubisa and Sheikh, 2013) as like current study it shows the particular species is showing lentic nature. Genus *Melania* (*Plotia*) and *Thiara* (*Tarebia*) were found to be highly restricted (stenotopic) to ponds, rivers and both rivers and confluence habitats, respectively. But other snail species, namely *Vivipara bengalensis* race *gigantica*, *V. bengalensis* race *mandiensis* and *M. striatella tuberculata* exhibited a wide range of distribution (eurytopic) and survival in various aquatic habitats (Choubisa and Sheikh, 2013).

During present study, the positive correlation of both the aquatic habitat shows that still the river is not much polluted and there is a hope of sustainable utilization of both the aquatic habitat in eco-friendly manner. Prabhakar and Roy (2008) also emphasised conservation and management of faunal diversity of the molluscan species. During present study, it was observed that in both the aquatic habitat, minimal density was observed during summer season and maximum during post monsoon season. It might be due to prevent for desiccation, molluscs buried self in mud and during monsoon season they came out due to favourable condition and started multiplication by means of breeding. During post monsoon season molluscan young ones were abundant both near to the shore area as well as inside the water. Comparatively it was observed that river Budhi Gandak having more species richness in relation to Muktapur maun it might be due to species nature. While studying the seasonal variation in macro benthic fauna of Gadigarh stream of Jammu, Dutta and Malhotra (1986) observed the predominance of molluscan fauna in the fishpond due to higher calcium concentration. Verma and Saksena (2010) observed 11 species of the molluscans from Kalpi (Marar) river from Ramaua reservoir, Gwalior, Madhya Pradesh. While studying the diversity of molluscan fauna Rajan and Murugan (2001) observed 4 species of molluscan at less polluted site and 2 species of molluscan at high polluted site and 5 species noticed at non polluted site of Arjuna river near Shivakshi Tamil Nadu

Since these molluscan species namely *L. acuminata*, *L. luteola*, *M. tuberculata* are highly

stenotopic or habitat-specific, hence they prove to be bio-indicators of ecologically diverse aquatic habitats (Choubisa and Sheikh, 2013). Many species of marine invertebrates exhibit a trend towards increased frequency of stenotopic species and sometimes this leads to elimination of eurytopes completely as in case of *Volutid neogastropods* (Hansen 1978), Variations are much more in the gene pool of stenotopes than eurytopes which make stenotopes long term survivors in the lineage. However, for further confirmation of habitat preference of freshwater snail species such surveys in different geographical regions are recommended. The significance of the present study is that these snail species can be used for identification and classification of freshwater habitats without going for detailed physico-chemical analysis of water.

Many molluscan species are good bio-indicators for paleo environments as well as for water quality or pollution on the basis of their tolerance power against extremes of physicochemical components of water (Harman, 1974; Edmondson *et al.*, 2010; Druart *et al.*, 2011). The biological communities that are exposed to pollutants act as integrators of multiple past and present environmental effects in any ecosystem. This attribute makes them suitable to act as bio-indicators (Cranston *et al.*, 1996) and indicate changes in condition and functioning of a system through change in their morphology / physiology/ genome organisation etc. They may be used to understand the response, adaptation and recovery of an ecosystem and its inhabitants to both natural and anthropogenic disturbances.

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