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A Study of the Environmental Impacts of the Gishori Industrial Complex on Plant Diversity in Tulkarm, Palestine

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Abstract

Plant diversity in Palestine in general, and in the West Bank in particular, requires elaborated investigations to highlight the status the existent plant species and the factors by which they are affected. Among the urgent issues that have emerged lately is the detection of the status of plant diversity in the Tulkarm area due the allocation of the Gishori Industrial Complex in this area. This was achieved via conducting floristic analysis to detect the possible effects of the presence of the Gishori Industrial Complex on different plant taxa levels in the Tulkarm area. Therefore, plant specimens were collected from an experimental area (Ertah: opposite to the factory) and a control area (Thenabeh: far from the factory) for which a floristic analysis, plant life-form examination as well as a comparative study were carried out in this research. The obtained results of the floristic analysis revealed the presence of fifty-seven and 110 plant species belonging to forty-five and eighty-nine genera and eighteen and thirty-five families in Ertah and Thenabeh, respectively. The plant life-form analysis showed that the dominant plant life-forms in Thenabeh and Ertah areas separately are annuals, hemicryptophytes, and chamaephytes (74 and 65 %; 31.4 and 25.4 % and 10.1 and 5.2 %, respectively). In conclusion, the higher plant diversity in Thenabeh compared with the Ertah area at different studied taxa levels can be attributed to the nearness of Ertah to the Gishori Industrial Complex in comparison to the remoteness of Thenabeh to this industrial complex.

Keywords: Plant diversity, Floristic analysis, Life-form, Pollution, Palestine

1. Introduction

Palestine is located at a meeting point between Europe, Asia, and Africa in the southeastern region of the Mediterranean Sea. This special location has contributed to the diversity of phytogeographic zones. In fact, historical Palestine has a rich biodiversity and unique ecosystems due to its significant bridge-like location between Europe, Asia, and Africa. It contains about 51,000 living species constituting approximately 3 % of the global biodiversity (EQA, 2015), which in turn caused a large diversity in the flora of Palestine. The different phytogeographic zones such as Irano-Turanian, Sudanian and Saharo-Arabian resulted from the region's climate and soil variations (EPD/IWACO-Euroconsult, 1994; Applied Research Institute-Jerusalem "ARIJ",2002; Ali-Shtayeh and Jamous, 2003). Despite its small area, the West Bank which is located in the Palestinian Territories (PT), comprises approximately 3 % of the world's biodiversity, and contains a high density of species as well as a large number of endemic species (ARIJ, 1997).

The Applied Research Institute of Jerusalem (ARIJ) reported that Palestine, (referred to as PT: Palestinian Territories) hosts 2500 species of wild plants with new ones discovered each year including 800 rare species and 140 endemic species (Isaac and Gasteyer, 1995). Also, 636 endangered species and 990 rare ones were recorded in Palestine (Safar *et al*., 2001; EQA, 2006). The West Bank, which is a part of Palestine, is also known for its unique forested areas, which comprise 4.45 % of the total area of PT. According to a recent survey carried out by a ARIJ team, 2076 plant species inhabit the West Bank and the Gaza Strip alone (75.5 % of the species are in Mandate Palestine), that is 1959 species belonging to 115 families grow in the West Bank and 1290 species of 105 families grow in the Gaza Strip, of which 117 species grow exclusively in the Gaza Strip. Out of the 2076 surveyed plant species which were observed to grow in the West Bank and Gaza, 636 are listed as endangered, of which ninety species are very rare. It is also contended by experts that urgent conservation measures are required for more than forty species (Sufian, 2001).

Few studies were carried out on specific areas of Palestine, which could be considered a contribution to the flora of each region on its own. For example, Boulos recorded 251 plant species belonging to forty-six families in the Gaza strip (Boulos, 1959). Later on, the Gaza strip coastal sand dunes were subjected to a study of the flora and life forms in which 120 plant species were recorded including fifty-one perennials, two biennials, and sixty-seven annuals. The recorded plant species belong to 109 genera and thirty-nine families (Madi *et al*., 2002). The same area was subjected to a similar investigation in which a higher number of 219 plant species belonging to 167 genera and fifty-five families was recorded. Moreover, the plant life-forms of the recorded plant species were investigated (Abou Auda *et al*., 2009). In addition, an ecological study and vegetation analysis for the Jericho district was conducted in which forty plant species were recorded (Jaffal *et al*., 2007).

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The floral survey of different localities in the West Bank helps create a mental picture of the area under study, by allowing the comparison and ultimate classification of different units of wild vegetation. Therefore, a documentation of wild plant diversity surveys of the flora of some West Bank localities was carried out (Omar, 2012). Later on, another study which considered the environmental situation and the plant diversity in several locations in the West Bank was conducted. It was an investigation of plant species, forest types, and deterioration while highlighting the green area in the West Bank (Al-Qaddi and Schirone, 2016).

Furthermore, among the urgent issues emerging lately is the detection of the flora and plant diversity status in the Tulkarm area. The Tulkarm District is a highly sensitive area characterized by many pine and olive groves on the west side of the city (Efe *et al*., 2009). The reason for the importance of such field of investigation is the presence of the Gishori Industrial Complex in this area and the effects of the potential environmental pollution caused by the industrial activities and waste on diminishing the region's plant diversity. One of the big environmental hazards facing the city of Tulkarm stems from the Nitzanei Shalom industrial zone known as the Gishori Industrial Complex located between Tulkarm and the village of Nitzanei Oz on the eastern side of the Green Line in the West Bank. The owner avoided the strict environmental laws moving the factory twenty kms to its current location on militarily expropriated land in the southern part of the city of Tulkarm.

In this study, pollutants such as heavy metals, dioxins, and others were analyzed in air, water and soil samples from the Tulkarm district. The analysis of some heavy metals in rain, soil, and ground water showed that the concentrations of these elements were higher in the areas close to the factories. For example, Pb, Ni, and Zn were highly detected in soil samples. In addition, interestingly, the rainwater sample analysis showed significantly higher amounts of Cl and NOx (Shahin *et al*., 2017). The highest concentration of these elements is expected to affect plants. This expectation is based on the fact that a large number of air pollutants, affect plant growth and their metabolism adversely by destroying chlorophyll and disrupting photosynthesis (Manahan, 2009). Accordingly, the Gishori industrial complex allocation in the Tulkarm area is expected to affect plant diversity in that region. In this respect, a comparison between the flora of the experimental area (Ertah: opposite to the factory) and the control area (Thenabeh: far from the factory) may enhance the understanding and determination of such effects.

The aim of the current plant diversity analysis is to highlight the diversity of the most common plant families in the West Bank-Tulkarm area of Palestine and to provide a floristic analysis of the studied area. In addition, this research intends to correlate this floristic analysis to the possible hazardous effects of the Gishori Industrial Complex allocation in the studied area. This aim has been achieved via a comparison of the flora of the experimental area (Ertah) and that of the control area (Thenabeh). It was broadly conceived that plant diversity in the experimental area (Ertah) will be less than that of the control area (Thenabeh).

2. Materials and Methods

2.1. Target Area

The city of Tulkarm is located in the northwest of the West Bank, south to Jenin, west to Nablus and adjacent to the "Israeli segregation wall". The district lies between 40 to 500 m above sea level, and is entirely within a fertile zone (ARIJ, 1996). Two regions in the Tulkarm district were targets for study in this project, which are Ertah near the Gishori Industrial Complex and Thenabeh located far from the Complex. The sites under examination were as natural as possible based on the type of vegetation in them, where wild plant species were observed to grow.

2.2. Plant Collection

The plant specimens were collected from their natural habitats through several field trips to Tulkarm district (Ertah and Thenabeh) over the period from April to June, 2015. The freshly-collected plant specimens were pressed till drying, then poisoned chemically using a mixture of mercuric chloride and ammonium chloride (150 gm of mercuric chloride, $HgCl_2$ and ammonium chloride, NH_4Cl, dissolved in as little water as possible) (Al-Esawi, 1977). Then, the poisoned plant specimens were fixed on herbarium sheets, and were identified and classified. After that, each plant specimen was provided with a voucher number and was deposited at the An-Najah herbarium, Department of Biology, Faculty of Science, An-Najah National University.

2.3. Plant Identification

Plant specimens' identification was carried out according to several floras. The plants were identified and classified based on their morphological features (Zohary, 1966a; 1966b; 1972a; 1972b; Dothan, 1978a; 1978b; 1986a; 1986b; Dothan and Danin, 1991; Boulos, 1999; 2000; 2002; 2005; Danin, 2004; Danin, 2018+).

2.4. Floristic Analysis

The floristic analysis of the flora of Tulkarm (Ertah and Thenabeh) was performed considering the plant species that exist and their classification and identification. The total number of the recorded plant species in the studied area was provided, and the same was done for the Ertah and Thenabeh areas. Moreover, the total of the genera and the number of families in the studied area were recorded. The percentage of the recorded taxa at the species, genera and family levels in the Ertah and Thenabeh areas in respect to the total recorded taxa was calculated using the following equation: The number of the recorded taxa/the total number of the recorded taxa x 100.

2.5. Plant Life-Form Analysis

The Raunkiaer system was adopted to determine the different plant life-forms in the studied area (Raunkiaer, 1934). The relative occurrence of each plant life-form was calculated using the following equation: The number of the plant species of specific life-form/total number of the recorded plant species x 100.

3. Results

3.1. Floristic Analysis

The floristic analysis of the collected wild plant species from the studied area in Tulkarm (Ertah and Thenabeh) showed a total of 135 plant species belonging to 105 genera and thirty-six families (Table 1).

The most abundant plant families recorded were Astraceae (Compositae) which comprises 32 plant species (24 %), Poaceae (Graminae) including 16 plant species (12 %) and the Fabaceae (Leguminosae) family with 14 plant species (10 %), while the other recorded plant families were represented by lesser numbers of species with variations recorded amongst them (Figure 1).

Table 1. The recorded plant species and their life forms in the studied areas of Ertah (near the factory; experimental area) and Thenabeh (far from the factory; control area) in Tulkarm.

Plant Family No.	Plant Family	Plant genus No.	Plant Genus	Plant species No.	Plant species	Region	Life form
1	Amaranthaceae	**1.**	*Amaranthus*	**1.**	*Amaranthus retroflexus* L.	Ertah	Annual
				2.	*Amaranthus muricatus* Gillies ex Hicken	Ertah	Annual
				3.	*Amaranthus viridis* L.	Thenabeh & Ertah	Annual
2	Apiaceae	**2.**	*Tordylium*	**4.**	*Tordylium trachycarpum* (Boiss.) Al-Eissawi & Jury	Thenabeh	Annual
		3.	*Artedia*	**5.**	*Artedia squamata*L.	Thenabeh & Ertah	Annual
		4.	*Daucus*	**6.**	*Daucus carota*L.	Thenabeh & Ertah	Hemicryptophyte
		5.	*Eryngium*	**7.**	*Eryngium creticum* Lam.	Thenabeh	Hemicryptophyte
		6.	*Foeniculum*	**8.**	*Foeniculum vulgare* Mill.	Thenabeh	Hemicryptophyte
		7.	*Pimpinella*	**9.**	*Pimpinella cretica* Poir.	Thenabeh	Annual
3	Asparagaceae	**8.**	*Asparagus*	**10.**	*Asparagus aphyllus* L.	Thenabeh	Geophytes, climber
		9.	*Scilla*	**11.**	*Scilla hyacinthoides* L.	Thenabeh	Geophytes
4	Asteraceae	**10.**	*Anthemis*	**12.**	*Anthemis palestina*Boiss.	Ertah	Annual
		11.	*Asteriscus*	**13.**	*Asteriscus aquaticus*(L.) Less.	Ertah	Annual
		12.	*Atractylis*	**14.**	*Atractylis cancellata*L.	Thenabeh	Annual
				15.	*Atractylis phaeolepis* Pomel	Thenabeh	Chamaephyte
				16.	*Atractylis serratuloides* Cass.	Thenabeh & Ertah	Chamaephyte
		13.	*Calendula*	**17.**	*Calendula palaestina* Boiss.	Thenabeh & Ertah	Annual
				18.	*Calendula arvensis* L.	Thenabeh & Ertah	Annual
		14.	*Glebionis*	**19.**	*Glebionis segetum* (L.) Fourr.	Ertah	Annual
				20.	*Glebionis coronarium*(L.) N.N. Tzvel.	Ertah	Annual
		15.	*Centaurea*	**21.**	*Centaurea hyalolepis* Boiss.	Thenabeh & Ertah	Annual
				22.	*Centaurea iberica* Spreng.	Thenabeh	Annual
				23.	*Centaurea verutum* L.	Thenabeh	Annual
		16.	*Cirsium*	**24.**	*Cirsium phyllocephalum* Boiss. & Blanche	Thenabeh	Hemicryptophyte
		17.	*Cichorium*	**25.**	*Cichorium endivia* L.	Ertah	Annual
		18.	*Cousinia*	**26.**	*Cousinia hermonis*Boiss.	Ertah	Hemicryptophyte
		19.	*Crepis*	**27.**	*Crepis aspera* L.	Thenabeh & Ertah	Annual
				28.	*Crepis palaestina* (Boiss.) Bornm.	Thenabeh & Ertah	Annual
				29.	*Crepis hierosolymitana* Boiss.	Thenabeh & Ertah	Hemicryptophyte
		20.	*Crupina*	**30.**	*Crupina crupinastrum* (Moris) Vis.	Thenabeh	Annual
		21.	*Echinops*	**31.**	*Echinops adenocaulos* Boiss.	Thenabeh & Ertah	Hemicryptophyte
		22.	*Hypochaeris*	**32.**	*Hypochaeris glabra* L.	Thenabeh	Annual
		23.	*Geropogon*	**33.**	*Geropogon hybridus* (L.) Sch.Bip.	Thenabeh	Annual
		24.	*Onopordum*	**34.**	*Onopordum blancheanum* (Eig) Danin	Ertah	Hemicryptophyte
				35.	*Onopordum cynarocephalum* Boiss. & Blanche	Thenabeh&Ertah	Hemicryptophyte
		25.	*Phagnalon*	**36.**	*Phagnalon rupestre* (L.) DC.	Ertah	Chamaephyte
		26.	*Pallenis*	**37.**	*Pallenis spinosa* (L.) Cass.	Thenabeh	Hemicryptophyte
		27.	*Picris*	**38.**	*Picris galilaea*(Boiss.) Eig	Ertah	Annual
		28.	*Lactuca*	**39.**	*Lactuca tuberosa* Jacq.	Thenabeh	Hemicryptophyte
		29.	*Scolymus*	**40.**	*Scolymus maculatus*L.	Ertah	Annual
		30.	*Sonchus*	**41.**	*Sonchus oleraceus* L.	Thenabeh	Annual
		31.	*Tragopogon*	**42.**	*Tragopogon coelesyriacus* Boiss.	Thenabeh	Hemicryptophyte
		32.	*Urospermum*	**43.**	*Urospermum picroides*(L.) F.W. Schmidt	Ertah	Annual
5	Brassicaceae (Cruciferae)	**33.**	*Sinapis*	**44.**	*Sinapis alba* L.	Ertah	Annual
		34.	*Biscutella*	**45.**	*Biscutella didyma* L.	Thenabeh	Annual
		35.	*Brassica*	**46.**	*Brassica napus* L.	Thenabeh & Ertah	Annual
		36.	*Sisymbrium*	**47.**	*Sisymbrium orientale* L.	Thenabeh	Annual
		37.	*Thlaspi*	**48.**	*Thlaspi perfoliatum* L.	Thenabeh	Annual
6	Boraginaceae	**38.**	*Anchusa*	**49.**	*Anchusa azurea* Mill.	Thenabeh	Hemicryptophyte
		39.	*Echium*	**50.**	*Echium judaeum* Lacaita	Thenabeh	Annual

		40.	*Heliotropium*	**51.**	*Heliotropium rotundifolium* Lehm.	Thenabeh	Chamaephyte
7	Cactaceae	**41.**	*Opuntia*	**52.**	*Opuntia ficus-indica*	Thenabeh	Chamaephyte
8	Campanulaceae	**42.**	*Campanula*	**53.**	*Campanula strigosa* Banks & Sol.	Thenabeh	Annual
		43.	*Legousia*	**54.**	*Legousia speculum-veneris* (L.) Chaix	Thenabeh	Annual
9	Capparaceae	**44.**	*Capparis*	**55.**	*Capparis zoharyi* lanocencio, Rivera et Alcaraz	Thenabeh	Hemicryptophyte
10	Caryophyllaceae	**45.**	*Dianthus*	**56.**	*Dianthus strictus* Banks & Sol.	Thenabeh	Hemicryptophyte
11	Convolvulaceae	**46.**	*Convolvulus*	**57.**	*Convolvulus betonicifolius*Mill.	Ertah	Geophytes, climber
		47.	*Cuscuta*	**58.**	*Cuscuta campestris*Yuncker	Ertah	Annual, parasite, climber
12	Cucurbitaceae	**48.**	*Ecballium*	**59.**	*Ecballium elaterium* (L.) A.Rich.	Thenabeh	Hemicryptophyte
13	Cyperaceae	**49.**	*Cyperus*	**60.**	*Cyperus distachyos* All.	Thenabeh & Ertah	Hemicryptophyte
				61.	*Cyperus longus* L.	Thenabeh & Ertah	Hemicryptophyte
				62.	*Cyperus rotundus* L.	Thenabeh & Ertah	Geophytes
		50.	*Carex*	**63.**	*Carex distans* L.	Thenabeh	Hemicryptophyte
14	Dipsaceae	**51.**	*Lomelosia*	**64.**	*Lomelosia prolifera* (L.) Greuter & Burdet	Thenabeh	Annual
		52.	*Pterocephalus*	**65.**	*Pterocephalus brevis* Coult.	Thenabeh	Annual
		53.	*Cephalaria*	**66.**	*Cephalaria joppensis* (Rchb.) Coult.	Thenabeh	Annual
15	Euphorbiaceae	**54.**	*Euphorbia*	**67.**	*Euphorbia berythea*Boiss. & Blanche	Thenabeh & Ertah	Annual
16	Fabaceae (Leguminosae)	**55.**	*Acacia*	**68.**	*Acacia raddiana* Savi	Thenabeh	Tree
		56.	*Anagyris*	**69.**	*Anagyris foetida* L.	Thenabeh	Phanerophyte shrub
		57.	*Astragalus*	**70.**	*Astragalus callichrous* Boiss.	Thenabeh	Annual
		58.	*Bituminaria*	**71.**	*Bituminaria bituminosa* (L.) C.H. Stirt.	Thenabeh	Hemicryptophyte
		59.	*Hippocrepis*	**72.**	*Hippocrepis unisiliquosa* L.	Thenabeh & Ertah	Annual
		60.	*Lupinus*	**73.**	*Lupinus pilosus* L.	Ertah	Annual
		61.	*Melilotus*	**74.**	*Melilotus indicus* (L.) All.	Thenabeh	Annual
				75.	*Melilotus sulcatus* Desf.	Ertah	Annual
		62.	*Ononis*	**76.**	*Ononis spinosa* L.	Thenabeh	Hemicryptophyte
		63.	*Trifolium*	**77.**	*Trifolium purpureum*Loisel.	Thenabeh	Annual
				78.	*Trifolium clypeatum* L.	Thenabeh	Annual
				79.	*Trifolium scutatum* Boiss.	Thenabeh	Annual
				80.	*Trifolium tomentosum* L.	Thenabeh	Annual
		64.	*Senna*	**81.**	*Senna italic* Mill.	Thenabeh	Chamaephyte
17	Gentianaceae	**65.**	*Centaurium*	**82.**	*Centaurium erythraea* Rafn	Thenabeh	Annual
18	Geraniaceae	**66.**	*Erodium*	**83.**	*Erodium malacoides* (L.) L'Her.	Thenabeh & Ertah	Annual
				84.	*Erodium moschatum* (L.) L'Her.	Thenabeh	Annual
19	Lamiaceae	**67.**	*Teucrium*	**85.**	*Teucrium capitatum* L.	Thenabeh & Ertah	Chamaephyte
		68.	*Micromeria*	**86.**	*Micromeria nervosa* Desf.	Thenabeh	Chamaephyte
20	Linaceae	**69.**	*Linum*	**87.**	*Linum pubescens* Banks & Sol.	Thenabeh	Annual
21	Malvaceae	**70.**	*Alcea*	**88.**	*Alcea setosa* (Boiss.) Alef.	Thenabeh	Hemicryptophyte
		71.	*Lavatera*	**89.**	*Lavatera cretica* L.	Thenabeh & Ertah	Annual
		72.	*Malva*	**90.**	*Malva sylvestris* L.	Thenabeh	Hemicryptophyte
22	Orobanchaceae	**73.**	*Orobanche*	**91.**	*Orobanche mutelii* F.W.Schultz	Thenabeh	Parasite
23	Papaveraceae	**74.**	*Papaver*	**92.**	*Papaver argemone* L.	Thenabeh	Annual
24	Phytolaccaceae	**75.**	*Phytolacca*	**93.**	*Phytolacca americana* L.	Ertah	Hemicryptophyte
25	Plantaginaceae	**76.**	*Plantago*	**94.**	*Plantago lanceolata* L.	Thenabeh	Hemicryptophyte
				95.	*Plantago afra* L.	Thenabeh	Annual
26	Poaceae	**77.**	*Schismus*	**96.**	*Schismus arabicus* Nees	Thenabeh & Ertah	Annual
		78.	*Aegilops*	**97.**	*Aegilops peregrina* (Hack.) Maire & Weiller	Thenabeh	Annual
				98.	*Aegilops biuncialis* Vis.	Thenabeh	Annual
				99.	*Aegilops geniculata* Roth	Thenabeh	Annual
		79.	*Alopecurus*	**100.**	*Alopecurus utriculatus* Banks & Sol.	Thenabeh & Ertah	Annual
		80.	*Andropogon*	**101.**	*Andropogon distachyos* L.	Thenabeh & Ertah	Hemicryptophyte
		81.	*Avena*	**102.**	*Avena sterilis* L.	Thenabeh&Ertah	Annual
				103.	*Avena longiglumis*Durieu	Thenabeh	Annual
				104.	*Avena sativa* L.	Thenabeh & Ertah	Annual
				105.	*Avena barbata* Pott ex Link	Thenabeh	Annual
		82.	*Corynephorus*	**106.**	*Corynephorus articulates* (Desf.) P.Beauv.	Thenabeh & Ertah	Annual
		83.	*Panicum*	**107.**	*Panicum maximum* Jacq.	Ertah	Hemicryptophyte
		84.	*Polypogon*	**108.**	*Polypogon monspeliensis* (L.)	Ertah	Annual

					Desf.		
				109.	*Polypogon viridis* (Gouan) Breistr.	Thenabeh	Hemicryptophyte
		85.	*Trisetaria*	**110.**	*Trisetaria glumacea* (Boiss.) Maire	Thenabeh	Annual
		86.	*Triticum*	**111.**	*Triticum aestivum* L.	Thenabeh&Ertah	Annual
27	Polygonaceae	**87.**	*Polygonum*	**112.**	*Polygonum arenarium*Waldst. & Kit.	Thenabeh	Annual
				113.	*Polygonum arenastrum*Boreau	Thenabeh&Ertah	Annual
		88.	*Rumex*	**114.**	*Rumex cyprius*Murb.	Ertah	Annual
				115.	*Rumex pulcher* L.	Ertah	Hemicryptophyte
28	Ranunculaceae	**89.**	*Adonis*	**116.**	*Adonis aestivalis* L.	Thenabeh	Annual
		90.	*Anemone*	**117.**	*Anemone coronaria* L.	Thenabeh	Annual
		91.	*Ranunculus*	**118.**	*Ranunculus scandicinus* (Boiss.) P.H. Davis	Thenabeh&Ertah	Annual
29	Resedaceae	**92.**	*Reseda*	**119.**	*Reseda alopecuros* Boiss.	Ertah	Annual
				120.	*Reseda alba* L.	Thenabeh	Annual
30	Rosaceae	**93.**	*Sarcopoterium*	**121.**	*Sarcopoterium spinosum* (L.) Spach	Thenabeh	Chamaephyte
31	Rutaceae	**94.**	*Haplophyllum*	**122.**	*Haplophyllum buxbaumii* (Poir.) G.Don f.	Thenabeh	Hemicryptophyte
32	Rubiaceae	**95.**	*Cruciata*	**123.**	*Cruciata articulate* (L.) Ehrend.	Thenabeh	Annual
		96.	*Valantia*	**124.**	*Valantia hispida* L.	Thenabeh	Annual
		97.	*Galium*	**125.**	*Galium setaceum* Lam.	Thenabeh	Annual
33	Scrophulariacea e	**98.**	*Verbascum*	**126.**	*Verbascum gaillardotii*Boiss.	Thenabeh	Hemicryptophyte
		99.	*Scrophularia*	**127.**	*Scrophularia rubricaulis* Boiss.	Thenabeh	Hemicryptophyte
34	Solanaceae	**100.**	*Solanum*	**128.**	*Solanum nigrum* L.	Thenabeh & Ertah	Hemicryptophyte
		101.	*Withania*	**129.**	*Withania somnifera* (L.) Dunal	Thenabeh	Chamaephyte
35	Urticaceae	**102.**	*Parietaria*	**130.**	*Parietaria judaica* L.	Ertah	Hemicryptophyte
				131.	*Parietaria lusitanica* L.	Thenabeh & Ertah	Annual
		103.	*Urtica*	**132.**	*Urtica pilulifera* L.	Thenabeh	Annual
				133.	*Urtica urens* L.	Thenabeh	Annual
36	Verbenaceae	**104.**	*Verbena*	**134.**	*Verbena supina*L.	Thenabeh	Annual
		105.	*Lantana*	**135.**	*Lantana camara* L.	Thenabeh	Phanerophyte shrub

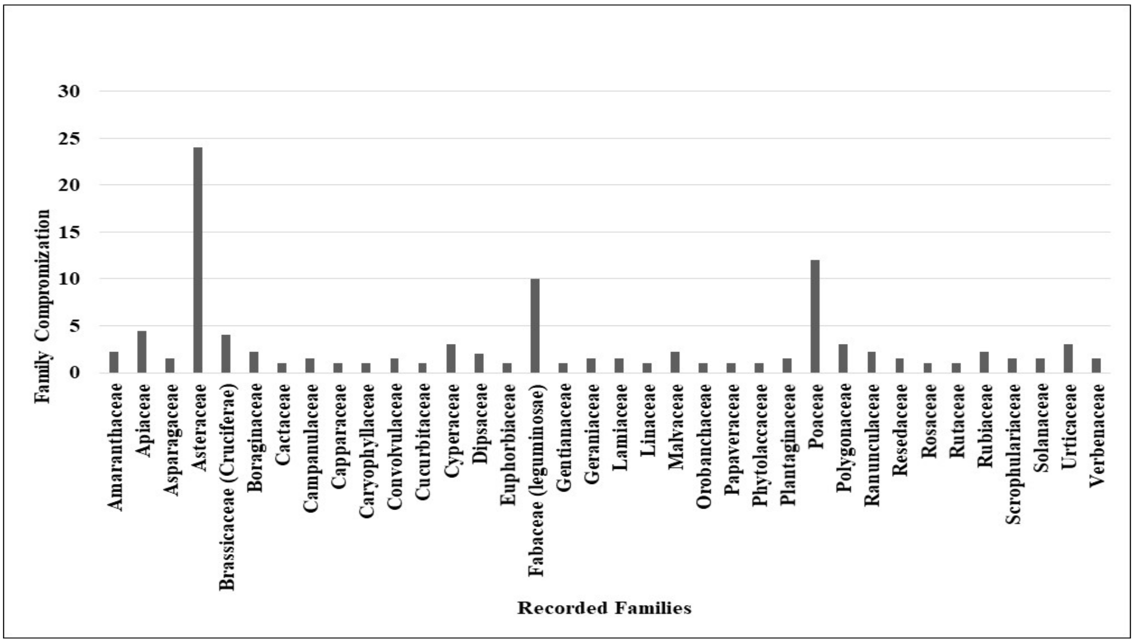

Figure 1. The recorded plant families in the studied area [Tulkarm: Ertah (near the factory; experimental area) and Thenabeh (far from the factory; control area)], with the total number of wild plant species/each family in respect to the total recorded plant species in Tulkarm.

The floristic analysis of the collected wild plant species from Ertah shows the presence of 57 plant species belonging to forty-five genera and eighteen families. The obtained results show that the plant diversity in Ertah area, at the site of the study that is opposite to the factory represents 50 %, 43 %, 42 % of the total plant diversity in the studied area (Ertah and Thenabeh) at the family, genera, and species levels, respectively. However, the floristic analysis of the collected wild plant species from Thenabeh reveals the presence of a total of 110 plant species belonging to eighty-nine genera and thirty-four families. Those recorded data illustrate that the plant diversity in Thenabeh area “control area” represents 94 %, 85 % and 81 % of the total plant diversity in the studied area at the family, genera, and species levels, respectively. Moreover, a comparative floristic analysis between Ertah near the Gishori Industrial Complex and the control area of Thenabeh may provide a closer view of the possible hazardous effects of the Gishori Industrial Complex waste materials on the plant diversity at different levels. Figure 2 shows that the Thenabeh area has had higher plant diversity than Ertah at different taxa levels.

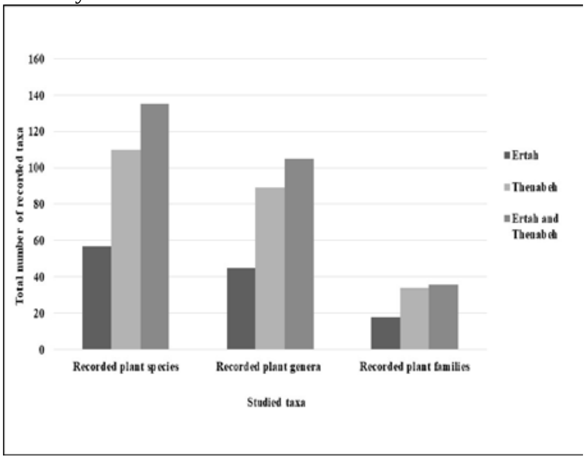

Figure 2. Total number of the recorded studied taxa at the plant family, genera and species levels in Ertah (near the factory; experimental area) and Thenabeh (far from the factory; control area) in Tulkarm, separately, compared to the total number of taxa in the studied area.

3.2. Plant Life-Form Analysis

The dominant plant life-forms are the annuals representing 60.7 %, hemicryptophytes constituting 24.4 %, and chamaephytes representing 7.4% of the total plant species. However, the other life forms of geophytes, geophytes climbers, phanerophyte shrubs, and parasites were represented by two species comprising 1.5 % of total species. Tree life-forms are represented by one species, which is *Acacia raddiana.* (Table 1). Similar results were recorded in Thenabeh and Ertah areas separately, where the dominant life forms included annuals, hemicryptophytes, and chamaephytes representing 74 % & 65 %; 31.4 % & 25.4 %, and 10.1 % & 5.2 %, respectively. However, variations in the plant life forms between Thenabeh and Ertah were observed; trees and phanerophyte shrubs were not recorded in Ertah (Table 2 and Figure 3).

Table 2. Plant life-forms in the studied area in Ertah (near the factory; experimental area) and Thenabeh (far from the factory; control area) in Tulkarm.

Plant life form	% of plant life-form in studied area in Tulkarm (Ertah and Thenabeh) in respect to total number of plant species in Tulkarm	% of plant life-form in Thenabeh in respect to total number of plant species in Thenabeh	% of plant life-form in Ertah in respect to total number of plant species in Ertah
Annual	60.7	74	65
Hemicryptophyte	24.4	31.4	24.5
Chamaephyte	7.4	10.1	5.2
Geophyte	1.5	2.2	1.7
Geophytes climber	1.5	1.1	1.7
Phanerophyte shrub	1.5	2.2	0
Parasite	1.5	1.1	1.7
Tree	0.7	1.1	0

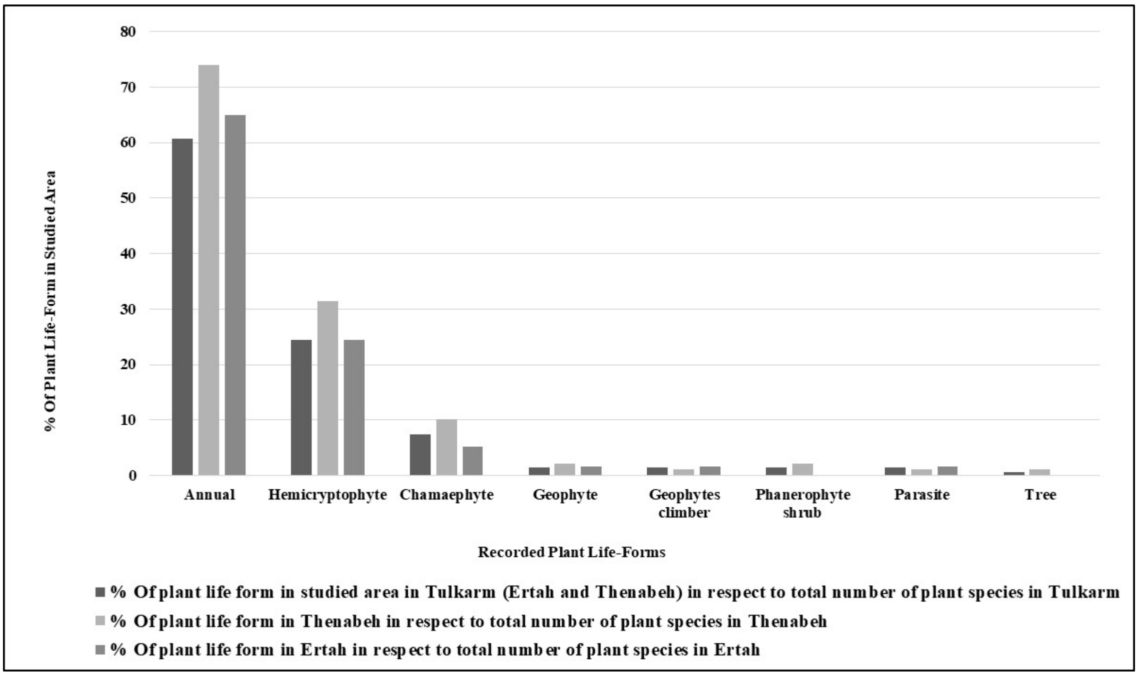

Figure 3. Biological spectrum showing the plant life-forms in Tulkarm [(Ertah (near the factory; experimental area) and Thenabeh (far from the factory; control area)], Ertah and Thenabeh, separately.

In addition, parasite life-forms were present in both areas represented by different species with one species in each area; that is *Cuscuta campestris* in Ertah and *Orobanche mutelii* in Thenabeh. Also, the geophyte climber life-form was represented by one species in Thenabeh and Ertah; these were *Asparagus aphyllus* and *Convolvulus betonicifolius*, respectively.

4. Discussion

One of the major biodiversity components is the number of plant species (species richness). Ecosystem spatial components, functional complementary, and interchange enhance the system stability and the ability to resist environmental disturbances and recover from them. Therefore, quantitative analyses of ecosystems' diversity, including species richness, improve the understanding of system stability and resilience in the face of disturbances (Ghattas, 2015). Such obtained quantitative information on plant diversity can help guide sustainable management strategies for a better conservation of ecosystems' resources.

Therefore, the importance of the current study of the environmental impacts on plant diversity is demonstrated via providing valuable information on the plant species recorded in Tulkarm taking into account that no previous scientific studies on that region were conducted. In addition, the obtained data regarding different taxa at the species, genera, and family levels can be considered a contribution to the studies of flora in the Tulkarm District. Moreover, the comparison between the recorded flora in Ertah and Thenabeh areas elucidates the hazardous effects of the construction of the Gishori Industrial Complex in this region on plant diversity taking into consideration that plant diversity is one of the most important vital parameters in ecosystem stability.

The dominance of the plant life-form of annuals in the studied area was as expected. Only annuals have seeds with perennating tissues. They are the most abundant life form in arid climates and are prominent in temperate areas with an extended dry season (Raunkiaer, 1934). Such conditions prevail in regions with Mediterranean climate conditions as in Tulkarm. The obtained data ascertain that the climatic conditions in Tulkarm enhance the prevalence of the annual life-form.

In spite of the limited period of study, the obtained data considering status of plant diversity in the examined area can provide a platform for further investigations of the extent to which the Gishori Industrial Complex waste products are affecting plant diversity in that region. This was reflected by the higher plant diversity at different taxa levels (species, genera, and family) in Thenabeh area compared with the Ertah area because of the nearness of Ertah to the Gishori Industrial Complex in comparison to the remoteness of Thenabeh to these industrial facilities. However, ongoing intensive and continuous flora surveys of the target region may reveal a wider spectrum of information on other plants that were not in their growing season during the period of the current study. Studies conducted over longer periods of time in this region can reveal and determine which of the wild plant species, if any, are endangered and threatened with extinction. In addition, more elaborate studies considering that aspect can be correlated with other biotic and abiotic factors in the region.

The observed variation between Thenabeh and Ertah areas in terms of some of the recorded plant species may indicate the difference in the physiological responses of such plant species to the possible effects of the factories' pollutants. The fact that some species are present in Ertah, but were not recorded in Thenabeh indicates that some plant species can tolerate or resist pollution caused by the factories of the Gishori Industrial Complex. Different factors affect the accumulation and distribution of heavy metals in plants. Among the major factors are the plant species, the levels of the metals in the soil and air, the element species and bioavailability, pH, cation exchange capacity, climacteric conditions, and the vegetation period (Filipović-Trajković *et al.*, 2012). For example, the Brassica species are identified as good candidates for phytoextraction of heavy metals especially Zn (Ramanjaneyulu and Giri, 2006). This might explain the presence of some Brassica species (*Sinapis alba* and *Brassica napus*) in the Ertah area where the soil samples were proved to have a high content of heavy elements such as Pb, Ni, and Zn (Shahin *et al*., 2017). Another study has discovered that high amounts of heavy metals were found in different plant species, one of which is *Rumex acetosella* (Filipović-Trajković *et al.*, 2012). This goes along with the presence of other *Rumex* species such as *Rumex cyprius* and *R. pulcher* (Polygonaceae) in Ertah.

However, some other plant species were only recorded in the Thenabeh area such as *Senna italica* (Leguminosae) and *Verbena supina* (Verbaneceae). Such plant species could be considered as sensitive plants to the Gishori Industrial Complex pollutants taking into consideration that they might not be found in Ertah due to pollution. Nevertheless, this finding could be confirmed and clarified via more elaborated long-term studies for both areas. In addition, investigating each pollutant from the factory on the recorded plant species may provide wider-spectrum images of the effects of the Gishori industrial complex on the recorded plant species. In fact, plant species which are considered sensitive to pollution might become endangered with the threat of extinction on the long run if pollution resulting from these factories extended to other areas in the Tulkarm district including Thenabeh.

5. Conclusions

In conclusion, correlating the obtained results with other parameters under study in the project may provide a clearer view of the extent to which the factories' presence in the studied area is affecting the ecosystem stability and threatening human life. Therefore, the outcome of the current project objectives may provide adequate information for decision-makers to take the right measures at the right time. It is clear from this study that the Gishori Industrial Complex is a source of pollution for the city of Tulkarm endangering its environment. Interestingly, the number of plant species near the factories reflects the effect of pollutants released in the soil and environment. More specific and detailed ecological analyses of the plant vegetation in the Tulkarm district, may reveal and determine the endangered plant species that are threatened with extinction. Also, ecological and vegetation analyses are required to determine the status of each plant species based on its frequency of occurrence and distribution to indicate the abundant plant species in the Tulkarm district. Such analyses of frequency and occurrence which can be correlated to the factory presence may subsequently help pass rigorous and strict laws and contribute to the governmental efforts for a better control of the establishment of factories. After all, this will develop and improve a scientific protocol for the conservation of wild plants in the Tulkarm area.

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