EVALUATING SOLAR DISINFECTION FOR POINT-OF-USE WATER TREATMENT IN NON-TROPICAL CLIMATES

by

Julia Parsons B.S., Environmental Engineering (2001) Massachusetts Institute of Technology

Submitted to the Department of Civil and Environmental Engineering in Partial to Fulfillment of the Requirements for the Degree of

> Master of Engineering in Civil and Environmental Engineering

> > at the

Massachusetts Institute of Technology

June 2002

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ABSTRACT

SOlar DISinfection (SODIS) is a simple water treatment method using natural solar radiation to inactivate pathogens commonly found in drinking water. This technology involves simply filling transparent PET bottles with contaminated water and exposing the bottles to direct sunlight. SODIS inactivates microorganisms via three mechanisms: (1) DNA alterations by UV, (2) production of photo-oxidative species and (3) thermal inactivation. SODIS works best between 35°S and 35°N. Outside of these regions, SODIS works sub-optimally because of the limited availability of solar radiation and the colder climate.

In order to assess the applicability of SODIS to colder climates, this study investigated two possible methods of ensuring that SODIS is effective under the conditions of lower temperatures and sunlight intensity: 1) enhancing the heating capacity of the bottle with black paint and 2) increasing the amount of radiation incident on the system using a solar reflector. Additionally, a mathematical model for predicting the expected bottle water temperature of each exposure regime, based on the ambient air temperature, wind, and available solar radiation, was developed. Such a model will be useful in future studies for assessing which type of exposure regime will be most effective.

Field studies were conducted in two locations in Haiti: Barasa and Dumay, and in Boston, Massachusetts, between the months of January through March, 2002. Analysis of the data collected showed that clear and half-painted bottles were most effective for microbial inactivation in non-tropical climates (Barasa and Boston). In Dumay, however, significant microbial inactivation was achieved in all bottles because the bottle water temperatures reached were much higher. There was no statistical significance between the amount of inactivation achieved by bottle on a reflector or without a reflector. However, because of the limited amount of data, further studies on the use of solar reflectors are recommended to assess their actual effectiveness.

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ACKNOWLEDGEMENTS

The author would hereby like to thank the following people for their contribution to this work:

My teammates, Sara Elice, Micahel Borucke, Arun Varghese, and my advisor, Daniele Lantagne for all their hard work and support.

Gift of Water representatives, Phil Warwick and Matt Cyr, for making this trip possible.

My friend, Karl Magdsick, for sharing his technical knowledge and providing emotional support.

The Don Don family in Barasa for their hospitality, and Diefu and my little helpers for making sure I had everything I needed in Barasa.

Peter Shanahan and Eric Adams for their help in developing the bottle water temperature model.

Nathan and Wanda Dieudonne and the Warwick family for their hospitality while I was in transit.

Fred Cote from the MIT Edgerton shop, for helping me design and build my solar reflectors.

And Amy Smith, for designing and building the phase-change incubator that made this research possible in rural Haiti.

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1 The Need for Clean Water

Access to clean drinking water is one of the world s most daunting development challenges. The United Nations Development Program estimates that 1 billion people today lack access to a safe, adequate water supply (Reed *et al.*, 2000). Clean water is essential to maintaining human health because waterborne pathogens cause diseases such as cholera, typhoid fever, and diarrhea (Cadgil and Shown, 1995). These pathogens usually originate from an infected host (either human or animal) and are transmitted by contaminated water through the fecal-oral route (Maier, 2000). There are over 800 million cases of diarrhea reported each year, of which about 5 million result in death (Wegelin, 1994). Waterborne diseases kill more than 400 developing world children every hour (Cadgil, 1995).

Waterborne diseases can be successfully controlled through the protection and treatment of water supplies. However, in the absence of treated water, people draw water from contaminated sources that contain the disease-causing pathogens such as bacteria, viruses, protozoa, and helminthes. Centralized water treatment facilities are common in developed countries but are considered too capital-intensive to be implemented in many developing countries (Cadgil, 1995). In addition, when such infrastructure does exist in developing countries, it is usually limited to urban communities.

1.1 Clean Water in Haiti

Haiti is both the poorest and most densely populated country in the western hemisphere (US Dept of State, 1998), and one of the poorest countries in the world. Eighty percent of the population lives below the poverty line (CIA, 2002), and seventy percent lives in rural areas (US Dept of State, 1998). Haiti has been plagued by political unrest for most of its history, and as a result lacks the resources for adequate water and sanitation infrastructure. Diarrhea is the leading cause of mortality in children under five years of age, with an incidence of 47 percent in 6-11 month olds (Pan American Health Org., 2002). As shown in Table 1.1, water related diseases are particularly common in rural areas where potable water is rare (USAID, 1985).

		Diarrhea		Intestinal Infections		Typhoid	
Area	Population	Cases	/1000	Cases	/1000	Cases	/1000
Port-au-Prince	6,500,000	6608	10.2	4694	7.2	460	0.7
Gonaives	33,000	255	7.7	167	5.1	11	0.3
Port-de-Paix	15,000	455	30.3	2171	145	114	7.6
Hinche	10,000	694	69.4	738	74	100	10.0
St-Marc	23,000	851	37.0	314	13.7	266	11.6
Petit-Goave	7,000	294	42.0	1357	194	2	0.3
Belladere	25,000	875	350	272	109	68	27.2
Jacmel	13,000	320	24.6	152	11.7	87	6.7
North Dept.	560,000	3145	5.6	6819	12.2	141	0.3
South Dept.	500,000	1909	3.8	2380	4.8	462	0.9

Table 1.1 Reported cases of water-related illnesses in 1980 (USAID, 1985)

1.1.1 Environment of Haiti

Haiti shares the island of Hispanola with the Dominican Republic, encompassing 27,750 square kilometers on the western one-third of the island (CIA, 2002). It is located roughly 600 miles south of Florida and 300 miles north of Venezuela, near the center of the West Indies, at 18° to 20° N latitude and 71° to 74° W longitude. It has two large peninsulas (Figure 1.1), called the northern and southern claws, which are separated by the Golfe de la Gon ve.



Figure 1.1 Map of Haiti (Lonely Planet, 2001)

The name Haiti comes from the Arawak word for 'mountainous land'. This name is more than fitting for Haiti, as 60 percent of all its terrain is on gradients of 20 percent or steeper (Lonely Planet, 2001). The main mountain ranges in Haiti include the Massif de la Hotte on the southern claw, the Massif de la Selle, running west to east just southeast of Port-au-Prince, and the Chaine du Bonnet in the north. Haiti also boasts astounding biodiversity, including 5,000 plant species and 25 endemic bird species. However, only two mammals native to the island still survive in Haiti: the Hispaniolan hutia (mole-like) and the solendon (long-nose rodent).

The climate of Haiti is generally hot and humid, with temperatures varying more over the course of a day than from season to season. Highs are generally around 30;C, while nighttime lows can reach 20;C. The summer in Haiti lasts from June to September, and can be slightly hotter than the winter (February to April), though temperatures drop markedly at higher elevations (Weil *et al*, 1985). Haiti also has a rainy season, which varies with region (in the north, October to May; and in the south, May to October), and a hurricane season, which usually lasts from June through September (Lonely Planet, 2001). Rainfall is usually from the North and East over the mountains. Thus there is more rain in the North and highlands (Weil *et al*, 1985).

One of the most detrimental environmental issues facing Haiti is that of deforestation. Ninety-eight percent of the original tropical forest in Haiti has been deforested for export crops and fuelwood (Lonely Planet, 2001). Deforestation also has detrimental impacts on water quality because of increased erosion of the now-barren hillsides. Erosion has also been the major cause of loss of rich topsoil to the sea, where it chokes the reefs and marine life. However, there are four national parks established in Haiti to preserve what is left of the remaining virgin forest: For t des Pins, in the southeast next to the Dominican border; Parc La Visite, with limestone caves and rainforests 40km southwest of Port-au-Prince; Parc Macaya, at the western end of Haiti's southern claw; and Parc Historique La Citadelle, in the center of the Massif du Nord, near Cap-Ha tien.

1.1.2 Assessment of water resources in Haiti

Only four percent of the governmental budget is allocated for potable water projects in Haiti, accounting for 15 percent of the total budget for such projects (USAID, 1985). The additional 85 percent of the funding for these projects comes from external assistance. There are two main organizations responsible for managing water resources in Haiti. The Centrale Metropolitaine d Eau Potable (CAMEP) is responsible for supplying water in the metropolitan area and the Service National d Eau Potable (SNEP) is responsible for rural water supply. Both organizations disinfect their water supply with chlorine, but this treatment is irregular and unreliable. CAMEP supplies water to approximately fifty percent of its potential customers and SNEP supplies approximately 39 percent (USAID, 1985). The rest of the population relies on private Haitian water vendors, whose water is from unprotected sources and rarely disinfected, or other local water resources such as wells and surface water.

The amount of water in Haiti, including surface water, groundwater, and springs, is believed to be sufficient supply for the entire population (USAID, 1985). However, these resources are limited by lack of access and proper treatment. Groundwater is believed to be abundant, particularly in the coastal plains where it is easy to access (Table 1.2). Groundwater is generally of better quality than surface water, for as water seeps through the soil to the water table, many microorganisms are removed (Lehr, 1980). Additionally, water quality often improves with storage in the aquifer because conditions are not favorable for bacterial survival. A properly constructed well (in addition to proper collection and storage methods) can ensure that the water remains clean and is safe for use.

Region	Number of Project Area	Number of Project Aquifers	Potential No. of Aquifers for which flow was estimated	Water flow (t/sec)
North and North Western Region	7	13	7	500-685
Artibonite Region	2	2	-	-
Southeast Coastal Region	3	5	2	399-1114
South Coast Region	5	3	2	530+
Central Plains Region	5	6	1	15-45
Total	22	29	12	1444-1844

 Table 1.2 Groundwater potentials for selected areas in Haiti (USAID, 1985)

Springs (places where groundwater has come to the surface) and surface waters are much more susceptible to bacteriological contamination than groundwater. Therefore, surface water should only be used when groundwater sources are unavailable or inadequate (Lehr, 1980). Surface water flow in Haiti is irregular, with short torrential flows during the rainy season and long periods of dryness - very few rivers have permanent flow (USAID, 1985). However, because groundwater in Haiti is often difficult to access, surface water and springs are the main water source for the Haitian people.

1.2 Gift of Water, Inc.

The main religion in Haiti is Christianity, predominantly Roman Catholic (U.S. Department of State, 1998). In Haiti the church is the foundation of the community. The church often coordinates community infrastructure such as schools, government, and facilities. Therefore, the Haitian people have a very high respect for the church and work associated with them.

One U.S. based organization that works mainly through the churches in Haiti is Gift of Water, Incorporated (GWI). In 1995, the non-profit Industry for the Poor, Inc. (IPI), (now Gift of Water, Inc.) was created by Phil Warwick to investigate clean water options for the people of Haiti. After conducting epidemiological studies in conjunction with the Adopt-A-Village Medical Mission, they developed an in-home gravity water filtration system (Figure 1.2) intended to reduce the presence of bacteria and volatile chemicals in the drinking water.



Figure 1.2 GWI gravity filtration system

The filter apparatus costs US\$15.29, but is subsidized by the program so that each family must only pay approximately US\$1.85 or even less (Anarchy, Inc., 2000). Operating expenses for each filter, including chlorination and granular activated carbon, amount to approximately US\$0.42 per year. Since being approved by the Haitian Ministry of Health, filters have been placed in seven villages across Haiti (Lantagne, 2001), serving over 22,000 people (Anarchy, Inc., 2000). Because of their extensive contacts and knowledge of Haiti, GWI representatives assisted in choosing appropriate study locations, and making arrangements for travel and research necessary for this study.

1.3 Point-of-use water treatment options for Haiti

The estimated cost of providing worldwide water supply coverage in developing countries is US\$150 billion (Wegelin, 1994). This cost cannot possibly be met by public funds, which are insufficient to even cover the costs of maintenance of the current infrastructure. An alternative to public water supply for people in developing countries is the use personal household water treatment systems, or point-of-use water treatment systems.

The most effective point-of-use water treatment usually consists of two stages: filtration and disinfection. In order to be most effective and appealing to it s users, a point-of-use water purification system should fulfill the following criteria (Lehr *et al.*, 1980; Shultz *et al*, 1984):

- Effective across a range of pathogens;
- Robust to changes in water quality;
- Effective in appropriate pH and temperature range;
- Should not make water toxic or unpalatable;
- Safe and easy to handle;
- Must provide residual protection against possible recontamination;
- Affordable;
- Adaptable to local conditions;
- Amenable to local production;
- Appropriate to local culture and customs;
- Comply with national sanitation standards;

Current household disinfection mechanisms include boiling water, filtration, and chlorination. However, boiling water requires energy in the form of fuelwood, which can be rare in rural areas of Haiti due to deforestation, and additionally exacerbate deforestation. The use of chlorine is often rejected by users because of the undesirable taste and odor associated with it, as well as because of its cost and unreliable supply and quality. Filtration techniques are also often unaffordable and such systems are subject to leaking and breakage. A more reliable and less expensive water disinfection technique is Solar Disinfection.

SOlar DISinfection (SODIS) is a simple water treatment method using natural solar radiation to inactivate pathogens commonly found in drinking water. This technology involves simply filling transparent PET bottles with contaminated water and exposing them to direct sunlight (Figure 1.3). SODIS utilizes the power of the sun to

inactivate microorganisms using UV-A radiation and increased temperature. Because this technology is so simple, both in concept and application, it is easily applicable in the developing world where safe water resources are scarce. However, the success of SODIS is dependent on a number of conditions, including climate and water clarity.

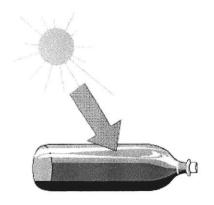


Figure 1.3 SOlar water DISinfection system

The pioneer of solar disinfection technology was Professor Aftim Acra, of the American University of Beruit (SANDEC, 2001). His work motivated the Integrated Rural Energy Systems Association (INRESA) to investigate the application of SODIS through a network project, which was reviewed at a workshop in 1988 organized by the Brace Institute of Montreal. In 1991 the Swiss Federal Institute for Environmental Science and Technology s (EAWAG) Department of Water Sanitation in Developing Countries (SANDEC) undertook extensive laboratory and field tests to analyze the effectiveness and social acceptability of SODIS as a low-cost water treatment method.

Currently SANDEC is promoting the use of SODIS by providing information, technical support, and advice on SODIS to institutions in developing countries worldwide (SANDEC, 2001). To date, successful SODIS studies have been completed in Columbia, Bolivia, Burkina Faso, Togo, Indonesia, Thailand, and China.

2 Application of SODIS

2.1 Mechanisms of Disinfection

The SODIS methodology utilizes both the infrared and ultraviolet spectra of radiation to disinfect water. The infrared spectrum is absorbed to generate heat and increase the bottle water temperature, and the ultraviolet spectrum directly inactivates microorganisms. The infrared spectrum is usually defined as electromagenetic radiation with wavelengths above 1000nm (10,000), and the ultraviolet spectrum is radiation with wavelengths between 4 and 400 nm (40-4000) (Koller, 1952), However, the atmosphere absorbs all radiation of wavelengths less than 200 nm (Parrish *et al*, 1978). Typically the remainder of the ultraviolet spectrum is divided into three portions: UV-C (200 to 290 nm); UV-B (290-320 nm); and UV-A (320-400 nm) (Figure 2.1). Of these, UV-A radiation is most abundant at the earth s surface.

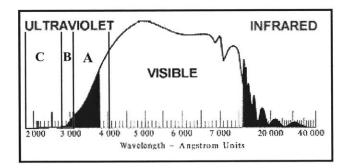


Figure 2.1 Electromagnetic Spectrum (Modified from PSU, 2001)

2.1.1 Thermal Inactivation

The first mechanism of disinfection utilized by SODIS is thermal inactivation of microorganisms. Microorganisms can only function within certain temperature ranges because of limitations of their metabolism. When these temperatures are exceeded, proteins and other macromolecules are denatured and the microorganism loses its ability to function properly (Madigan, 2000). It is possible to disinfect drinking water without

reaching boiling temperatures. This process, known as pasteurization, is different from sterilization in that sterilization inactivates all microorganisms, including heat-resistant spores. However, heat-resistant spores are harmless for humans to eat, and thus pasteurized water is sufficient for drinking purposes. For *E. coli*, a pathogen causing diarrhea, pasteurization occurs above 70° C (Wegelin et al,1994).

Microbial inactivation is also possible at temperatures below pasteurization temperatures. Between 20 to 40°C, the inactivation rate of fecal coliforms remains constant (Wegelin et al,1994). Above temperatures of 50°C, microbial inactivation is enhanced through the synergistic effects of UV and temperature. At temperatures lower than 20°C however, the thermal inactivation effects are negligible and therefore photobiologic effects (i.e. UV and photo-oxidative) are the main modes of disinfection.

The temperature of the SODIS system is increased by the absorbance of both long and short wave radiation by the bottle and the water, which then generates heat in the system. Some of this heat is re-emitted as back-radiation from the bottle into the atmosphere. Additionally, the system gains or looses heat through convective exchange with the air. The addition of wind can enhance convective exchange, thus increasing the rate of heating/cooling. In order to prevent rapid cooling, a wind-shield would be desirable to protect the bottles from heat loss, provided the shield does not shade the bottles. Additionally, uneven exposure can cause uneven heating, which causes a thermal gradient and induces circulation in the bottle (Wegelin *et al.*, 1994).

Because it is difficult to determine when water reaches pasteurization temperatures without thermometers, a device known as a Temperature Sensor has been developed for use in developing countries (SANDEC, 2001). This device contains soy wax, which melts just below pasteurization temperatures. When the wax melts it drops to the bottom of the indicator, so that even if the water cools again it is obvious that the threshold temperature was reached.

2.1.2 UV Induced DNA Alterations

Another inactivation mechanism of solar disinfection is the direct effects of UV induced DNA alterations. Ultraviolet radiation is more biologically active than visible light because it is made of higher energy photons (Parrish *et al*, 1978). When photons are absorbed, all of their energy is transferred to the absorbing atom or molecule, which brings it to an excited state. While in this excited state, changes may occur in the molecule such as rotation, vibration, or changes to the orbital shells. Ultimately, photochemical reactions may be induced if the energy of the absorbed photon is greater than or equal to the activation energy required for a reaction. The typical activation energy for most biological photochemical reactions is between 40 and 100 kcal/mol, making UV light highly effective in causing photobiologic effects because of the amount of energy it contains (Table 2.1).

UV Band	Wavelength	Energy (kcal/mol)		
UV-C	200	143		
	250	114		
UV-B	280	102		
	300	95		
UV-A	360	79		
	420	72		

Table 2.1 Energy associated with various ultraviolet wavelengths (Parrish, et al, 1978)

The alteration of DNA molecules by UV radiation is the result of photochemical reactions within the cell. The peak amount of energy that can be absorbed by many bacteria corresponds to a wavelength of 260 nm, which is the maximum for absorbance by aromatic amino acid residues and their proteins (Parrish *et al*, 1978). Therefore, it appears that UV-C and UV-B radiation would be the most effective in the inactivation and killing of bacteria through photochemical alteration of cellular DNA. However, studies have shown that 10^4 - 10^5 times more UV-A radiation (either intensity or exposure time) can have the same inactivation effect as the lower wavelengths.

Because DNA has a maximum UV absorbance of approximately 260 nm, exposure to radiation of lower wavelengths causes mutagenesis, resulting in death of the cell (Raven and Johnson, 1996). UV light absorbed by microbial DNA causes the covalent bonding of adjacent bases (commonly thymine-thymine, cystosine-cystosine, and thymine-cystosine), which form pyrimidine dimers (Figure 2.2) (Parrish *et al*, 1978). DNA replication is prevented by this mutation because nucleotides either cannot properly pair with the thymine dimers, or the dimers are replaced with faulty base pairs. If these mutations are perpetuated they prevent protein synthesis, which blocks metabolism and causes the organism to die.

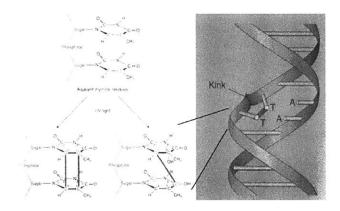


Figure 2.2 Formation of pyrimidine dimers in DNA

Additionally, hydrated pyrimidines, cross-linked DNA, DNA strand breakage, local disruption of hydrogen bonds, and changes to RNA can occur when cells are irradiated with UV (Parrish *et al*, 1978). All of these result in disrupted RNA synthesis and cell replication, likely resulting in death. Cell protein structure; and enzyme activity are also affected by UV irradiation, but in comparison to the effects of DNA disruption, they are negligible.

Some microorganisms have adapted to UV exposure by the production of repair enzymes and protective pigments. In most microbial populations the resistant fraction comprises only 0.01 percent, though some studies suggest it can be as high as 10 percent for certain species (Kowalski and Bahnfleth, 2000). In cases of massive exposure, damage is too extensive for these mechanisms to repair. UV-A radiation has also been shown to damage these DNA repair mechanisms (Parrish *et al*, 1978). For example, the photoreactivating enzyme is both destroyed and activated by UV-A, and excision repair and single strand break repair mechanisms may be inhibited. Additionally, UV-A of about 365nm appears to alter active transport processes, proteins, and other enzyme activities.

According to SANDEC News, No. 3, total solar energy of 555 W/m^2 is necessary to induce these lethal UV effects at temperatures between 20-40°C. This is equivalent to mid-latitude, midday summer sunshine (Wegelin, 1994). At temperatures of 50°C, only one-third as much energy is required for equivalent disinfection. Therefore, exposure to sunlight of lower intensity for longer periods of time would provide the same amount of total energy as higher intensity sunlight for a shorter period of time. Therefore, for the application of SODIS, the less radiation that is available, the longer exposure time is necessary to achieve sufficient microbial inactivation.

Solar radiation also attenuates with depth through water. Therefore, shallower water parcels will be exposed to more intense radiation than deeper parcels. However, circulation induced by the thermal gradient would ensure that each water parcel is exposed to direct radiation (Wegelin *et al.*, 1994).

2.1.3 Photo-Oxidative Disinfection

A third mechanism of disinfection that is utilized by the SODIS system is photooxidative disinfection. Highly reactive forms of oxygen, including oxygen free radicals and hydrogen peroxides, are formed in well-oxygenated water when exposed to sunlight (SANDEC, 2001). These species are so reactive that they can cause serious damage to living cells if formed in significant amounts (McKee and McKee, 1999). These reactive forms of oxygen inactivate microorganisms by oxidizing microbial cellular components, such as nucleic acids, enzymes, and membrane lipids (Reed, 1996). This damage results in enzyme inactivation, polysaccharide depolymerization, DNA breakage, and membrane destruction. These mechanisms either prevent proper cell replication or cause mutations, which are propagated through replication.

2.2 Required Conditions for SODIS

2.2.1 Weather and Climate

The optimal region for use of SODIS is between 15° and 35° N latitude (Figure 2.3), a region characterized by high solar radiation and limited cloud coverage (the second most optimal region for SODIS is between the equator and 15°N latitude) (SANDEC, 2001). It should be noted that the majority of developing countries lie within this region. According to SANDEC, within this region and during optimal weather conditions (less than 50 percent cloudy), the contaminated water needs to be exposed for 6 hours to achieve total disinfection. If the sky is more than 50 percent cloudy, or the bottle water temperature does not exceed 42°C (necessary to induce synergistic effects), the bottle should be exposed for two consecutive days.

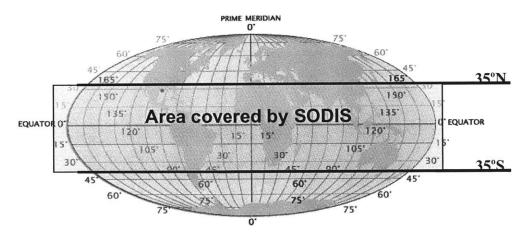


Figure 2.3 Effective area for SODIS application.

For practical application of SODIS in developing countries, where there is no accurate way of judging cloud cover or bottle water temperature, an exposure time of two days has been recommended as the standard SODIS procedure (Oates, 2001). Outside of the regions mentioned above, SODIS works sub-optimally because of the limited

availability of solar radiation and the colder climate. Often longer exposure can ensure the effectiveness of SODIS under these conditions, as the UV and photo-oxidative effects of the sunlight dominate the disinfection process, as opposed to thermal effects. However, the optimal length of exposure under different conditions has not been extensively investigated in the literature.

2.2.2 Turbidity

In order for SODIS to be effective, the water must be relatively clear (turbidity less than 30 NTU) (SANDEC, 2001). This is because suspended particles in the water can absorb solar radiation, thus reducing the depth to which solar radiation penetrates and protecting some microorganisms from radiation. Therefore, water with turbidity greater than 30 NTU would need to be filtered or bottle water temperature of 50°C must be reached in order to achieve pasteurization.

In order to overcome the technical burden of exactly measuring turbidity, SANDEC has developed a simple method for determining whether or not water is suitable for SODIS. For this method, a full bottle is placed on top of the white SODIS logo in the shade. If the logo can be seen through the bottle, then the turbidity can be assumed to be less than 30 NTU. If the results are questionable, a higher turbidity should be assumed and the water treated accordingly (SANDEC, 2001). Such treatment may necessitate filtration, though usually allowing particles to settle and decanting the water off the top is sufficient.

2.2.3 Oxygen

In order to maximize the production of photo-oxidative species in the water, it is necessary to make sure the water is well aerated. In order to do this, one can shake the bottle when it is only half full, and then fill it completely (SANDEC, 2001). This technique should especially be applied to stagnant waters, such as from cisterns and wells. Reed (1997) recommends repeating this process hourly to ensure aeration is maintained. However, the effectiveness of this repeated agitation has been questioned by

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Kehoe, et al. (2001). They found that repeated agitation had no effect on the amount of inactivation achieved.

2.2.4 Container Material and Design

The most common type of container used for SODIS are PET (PolyEthylene Terepthalate) bottles. These bottles are preferred because they are commonly available, more lightweight and durable than glass, and are more chemically stable than other plastics. However, glass bottles have higher transmittance than plastic bottles (75 percent for glass versus 70 percent for plastic), so some transmittance is lost in using plastic bottles. Plastic bags have an even higher transmittance (90 percent), but are significantly less durable than either glass or plastic bottles and are also difficult to use.

PET bottles can easily be distinguished from other bottles because of its clear appearance as compared to PVC, which has a bluish gleam. Additionally, PET burns more easily than PVC and the smell is sweeter than that of PVC. However, one significant drawback to the use of these bottles in comparison to glass is the rate at which they age due to mechanical scratches and the production of photoproducts, which leads to a reduction of UV transmittance (SANDEC, 2001). Because these bottles are commonly available in the developing world, this is not considered a significant problem because aged bottles can be easily replaced.

Another concern with the use of PET bottles is the possible formation of photoproducts on the plastic material as a result of UV-irradiation. These photoproducts are the result of the migration of additives out of the material, such as the UV stabilizers that are used to increase the plastics stability (SANDEC, 2001). However, in PET these additives are used less than in PVC (less than one percent of the PET components). Laboratory and field test addressing this concern have shown that these products are generated only on the outer surface of the bottles, and no migration into the water was observed.

In addition to the container material, one must also consider the size and shape of container most effective for SODIS. Because UV radiation attenuates with depth (50 percent attenuation at 10 cm with turbidity of 26 NTU), containers with a large exposed surface area to volume ratio are recommended. PET bottles used for SODIS have a sub-optimal shape because this ratio is small (SANDEC, 2001). With a water depth of 6-10cm, the water is not as evenly exposed to radiation as in a flatter container, such as a bag. However, this uneven exposure can cause uneven heating, which causes a thermal gradient and induces circulation in the bottle, which would ensure that each water parcel is exposed to direct radiation at some time (Wegelin *et al.*, 1994). Thus, although containers with a larger exposed area to volume ratio would be more efficient, in the developing world, one must learn to efficiently use whatever is available.

2.3 Limitations

Although SODIS seems to be the ideal solution for drinking water disinfection, as it requires no chemicals or technical expertise, it does have limitations. First, SODIS does not improve the chemical water quality, though studies are being undertaken to assess the effectiveness of UV-radiation in arsenic abatement, nor does it change the smell or taste of the water (SANDEC, 2001). The effectiveness of SODIS is also dependent on climate and certain water quality parameters, such as turbidity and dissolved oxygen, as discussed above. However, the user can easily adjust both of these parameters so that SODIS is effective (filtering/settling to reduce turbidity, mixing to increase oxygen). Additionally, SODIS offers only a very limited production capacity because of the limitations to bottle size/shape available, and therefore may not be a feasible solution for generating large quantities of clean water.

3 Research Goals

In order to assess the applicability of SODIS to colder climates, it is necessary to investigate possible ways of modifying the present system so as to make most efficient use of the available conditions. Though the area in which SODIS should be applicable based on the amount of available sunlight is very broad, some of the locations that fall within this region occasionally experience climate conditions not optimal for SODIS use due to elevation and seasonal variances. For example, the winter season has higher cloud cover associated with colder temperatures, during which SODIS may not be effective. Additionally, at higher altitudes, although sunlight intensity may be stronger, cloud cover is also much more common and temperatures much cooler.

Two possible methods to ensure that SODIS is effective under the conditions of lower temperatures and sunlight intensity are: 1) to enhance the heating capacity of the bottle or 2) to increase the amount of radiation incident on the system. The former can be achieved by painting the bottles with black paint, which absorbs solar radiation and converts it to heat energy. The later can be achieved through the use of solar reflectors to gather and focus UV onto the bottle. The purpose of this thesis was to investigate the effectiveness of both of these methods in sub-optimal climate conditions.

3.1 UV enhancement

Most metals are good reflectors for both visible and ultraviolet light (Koller, 1952). The efficiency of reflection depends on the cleanliness of the surface and absence of impurities. Aluminum is one of the most commonly used reflective metals because it is relatively inexpensive, easy to use, and resistant to corrosion. It is considered one of the most suitable for UV applications (Parrish, 1978). The shape of the reflector also influences the effectiveness of reflection. Parabolic reflectors are particularly good for focusing light on one point. However, their round shape would not efficiently focus light

on the elongated SODIS bottles. Flat reflectors on the other hand, are less efficient because they do not focus the light at all.

The reflector used in this study consists of two parallel "slings" of reflective material supported by rope (clothesline) hung between two wooden base pieces (Figure 3.1). One reflector was built using aluminum coated mylar and another was built using materials that would be available in a developing country (aluminum foil supported by a plain brown paper). Each "sling" held three bottles end-to-end (for a total of six bottles per reflector). The reflector should be oriented parallel to the path of the sun (approximately east to west) so as to minimize shadows (Figure 3.2).

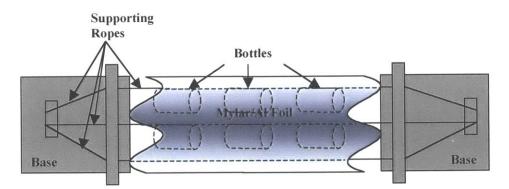


Figure 3.1 Top view of solar reflector used



Figure 3.2 Solar reflectors, Left: aluminum foil, Right: aluminum mylar

All reflectors use in this study were built at MIT and designed to be transportable, and so had to be light and compact. Therefore, these reflectors consisted of numerous small parts, which were easy to reassemble (see assembly instructions in the research plan in Appendix I) The dimensions of such reflectors could be optimized based on the size of the bottles used, however, the bottle size for each location of this study was not known at the time the reflectors were built. Therefore they may not have been as effective as was possible, though it is estimated that no more than 20 percent effectiveness was lost.

3.2 Thermal enhancement

The recommended SODIS procedures call for painting bottles half black to enhance the heat absorbance capacity of the system (SANDEC, 2001). Theoretically, this increases the bottle water temperature by 5°C by absorbing extra radiation. However, the amount of temperature increase is dependent on the available amount of radiation to be absorbed and the area and orientation of the surface painted black. This study investigated the thermal enhancing effects of painting bottles both half black and fully black to see if threshold temperatures could be reached despite low ambient air temperatures in areas where radiation is abundant. The bottles were painted using locally available flat black paint, following the procedure outlined in the research plan in Appendix I.

The purpose of painting the bottles half black is allow for both thermal enhancement as well as UV disinfection, whereas the fully painted bottle will rely on thermal inactivation alone. Therefore the fully painted bottles must reach the threshold temperature of 50°C to achieve disinfection. These temperatures were not necessary in the clear and half painted bottles because UV disinfection would be active in these bottles.

The main mechanism of heat gain in the SODIS system is the absorbance of solar radiation. Additionally, if the ambient air temperature is greater than the bottle water temperature, some heat gain will be made through natural convection. However, because the amount of convection over two bottles of the same size would be equal, the difference

in temperature reached in the fully painted bottle versus the half-painted bottle is mainly dependent on the difference in the amount of radiation absorbed by the different systems. Therefore, it is also possible that the use of a solar collector/reflector could contribute to increased bottle water temperatures by increasing the amount of radiation incident on the bottles.

3.3 Bottle Water Temperature model

In addition to evaluating the above techniques for enhancing the effects of SODIS, this project also developed a mathematical model for the bottle water temperature under various conditions. Such a model would be useful for evaluating the suitability of SODIS in a particular locale and the techniques that should be used to enhance its effectiveness. The model is dependent on the local weather conditions over the appropriate period of time:

> $T_a(t)$ = ambient air temperature [K] R(t) = total solar radiation [W/m²] U(t) = wind speed [m/s]

In order to achieve an accurate model of the exact bottle water temperature under given conditions, these parameters must be monitored *in situ*. However, for the purposes of evaluating the effectiveness of SODIS, approximate weather conditions can be generated using a weather model or gathered from a local weather station to estimate best- and worst-case scenarios.

The model is also dependant on characteristics of the bottle and the water, including:

D = bottle diameter [m] x = bottle thickness [m] k_p = thermal conductivity of plastic [W/mK] M = mass of water [g]

C_v = heat capacity of water [J/gK]

This model cannot substitute for *in situ* field tests to evaluate the actual effectiveness of SODIS. These tests are still necessary to make recommendations for factors that are more site specific, such as exposure time and necessary water pre-treatment. However, the results of the model can predict whether thermal enhancement measures would be effective or not.

There are four main heat flux components to this model: (1) heat generated by short-wave radiation absorbed by the system (Q_R), (2) heat gain through absorption of long-wave radiation (Q_L), (3) heat loss through long-wave radiation from the system (- Q_b), and (4) heat gain/loss by convection (Q_C). Therefore, at each time step the net heat flux into the system (Q_T) is the sum of these quantities:

$$Q_{\rm T} = Q_{\rm R} + Q_{\rm L} + Q_{\rm C} - Q_{\rm b} \qquad (\text{Equation 1})$$

The net heat flux can then be used to find the change in bottle water temperature over a single time step:

$$dT = \frac{Q_T}{C_v \cdot M} dt \qquad (Equation 2)$$

where dt is the length of the time step used, in seconds. It should be noted that in comparison to the mass of the water, the mass of the bottle, and thus the heat capacity of the bottle, is negligible.

3.3.1 Absorption of short-wave radiation

The main difference in the bottle water temperature in the painted versus unpainted bottles will be the amount of short-wave solar radiation absorbed (i.e. wavelengths shorter than 3000nm). Each regime will absorb a different amount of solar energy based on the amount of surface area painted black (Figure 3.3).

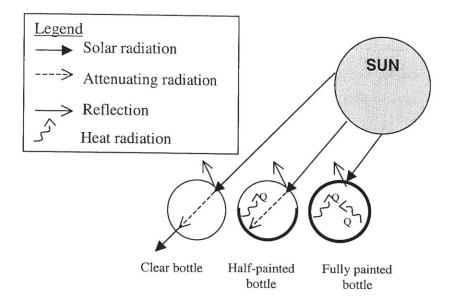


Figure 3.3 Diagram of short-wave solar radiation absorbed by the different bottle regimes

Ideally, the fully painted bottle will absorb all available radiation, and thus the heat flux into the bottle due to solar radiation would be equal to:

$$Q_R = R \cdot A_x$$
 (Equation 3)

where A_x is the cross-sectional area of the bottle, over which direct radiation is absorbed. In part this equation will underestimate the heat flux because it does not account for scattered radiation absorbed by the system. However, it is also an overestimate because it assumes 100 percent efficiency.

For the half painted bottle not all radiation is absorbed because some radiation is reflected off the unpainted surface. Therefore, for the half painted bottle, the amount of solar radiation absorbed is determined by:

$$Q_{R} = (1-\varepsilon) \cdot R \cdot A_{x}$$
 (Equation 4)

where ε is the percent of the total solar radiation reflected by the bottle.

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The water in the clear bottle will also absorb some radiation, which is why the intensity of the radiation attenuates with depth as mentioned in Section 2.1.2. For the clear bottle, there will also be reflection off the clear surface. Therefore, the amount of radiation absorbed by the clear bottle system is calculated by:

$$Q_{R} = \eta \cdot (1 - \varepsilon) \cdot R \cdot A_{x} \qquad (Equation 5)$$

where η is percent radiation attenuation.

3.3.2 Absorption and emission of long-wave radiation

In addition to short-wave radiation, long-wave radiation also has the potential affect the amount of heat in the system. The amount of radiation transmitted through the material is dependent on the properties of the material. All the radiation that is transmitted through the plastic will be absorbed by the water. This amount is determined by:

$$Q_{L} = \alpha \cdot \sigma \cdot T_{a}^{4} \cdot A_{s} \qquad (Equation 6)$$

where α is the percent of long-wave radiation that is transmitted by the bottle, σ is the Stefan-Boltzman constant (5.67E-8), T_a is the ambient air temperature and A_s is the total surface area of the bottle through which radiation can be absorbed.

The amount of long-wave radiation lost by the system (often referred to as back radiation) is determined through a similar calculation:

$$Q_{b} = \varepsilon \cdot \sigma \cdot T_{s}^{4} \cdot A_{s} \qquad (Equation 7)$$

Where ε is the bottle emissivity, and T_s is the bottle surface temperature.

3.3.3 Convection

The direction of heat flow due to convection is dependent on the thermal gradient across the bottle wall. If the air temperature is warmer than the bottle water temperature, than the direction will be into the bottle, but if the air is cooler than the water, heat flow will be out of the bottle. The rate of this heat flow is enhanced by wind flow over the bottle, which increases the number of parcels of air that come in contact with the bottle (Figure 3.4).

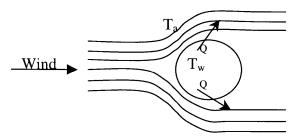


Figure 3.4. Diagram of convective heat exchange with wind

For an open water surface, this heat exchange would be governed by the equation for convective heat loss. However, because the plastic bottle acts as a resistor to heat flow, the equation for conductive heat loss is more applicable

$$Q_{\text{cond}} = \frac{(T_{\text{s}} - T_{\text{w}}) \cdot k_{\text{p}} \cdot A}{X}$$
(Equation 7)

where T_s is the temperature on the outer surface of the bottle, T_w is the bottle water temperature, k_p is the thermal conductivity of the plastic, A_s is the surface area of the bottle and x is the thickness of the plastic. T_s can be found by equating conductive heat flow through the bottle to convective heat flow across the bottle surface (Figure 3.5):

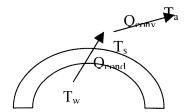


Figure 3.5 Diagram of convection and conduction

$$Q_{conv} = h \cdot A \cdot (T_a - T_s)$$
(Equation 8)
$$Q_{cond} = Q_{conv}$$
(Equation 9)

$$h \cdot A \cdot (T_a - T_s) = \frac{(T_s - T_w) \cdot k_p \cdot A}{X}$$
 (Equation 10)

where $h = Nu \cdot k_a/D$, Nu is the Nusselt number (as calculated in Appendix III), and D is the bottle diameter. Therefore,

$$T_{s} = \frac{\{((Nu \cdot k_{a}/D) \cdot T_{a}) + (k_{p} \cdot T_{w}/x)\}}{\{(k_{p}/x) + (Nu \cdot k_{a}/D)\}}$$
(Equation 11)

The Nusselt number is dependent on the type of convection (free versus forced) and the shape of the surface over which convection is occurring. Convection over the end of the bottle will be different than convection over the cylinder. Therefore, different calculations must be made for convection over the end and convection over the cylinder, and then summed to find the total convection.

3.4 Summary of Research Goals

The main goal of this thesis was to evaluate SOLar DISinfection for use in nontropical climates. Two methods for enhancing its effectiveness under such conditions were investigated: 1) use of black paint to enhance the thermal effectiveness of the system, and 2) use of solar reflectors to enhance the optical effectiveness of the system. In addition, a simple model for predicting the bottle water temperature was developed and evaluated to supplement *in situ* studies and pre-determine the type of exposure regime that would be most effective in a given climate.

4 Research Outline

4.1 Location, Climate and Water Supply

Experiments for this study were carried out during the months of January, February, and March 2002. The month of January was spent conducting studies in two locations in Haiti: the rural community of Barasa and the more urban center of Dumay. Follow-up studies were then conducted throughout February and March in Boston, Massachusetts, USA. All of Haiti falls within the optimal latitudes for application for SODIS, and so the locations in Haiti were chosen based on their disparate weather conditions, which are due mainly to differences in elevation.

The process for collecting water from the source and transferring it into the SODIS bottles varied with location and ease of access to the source. In some cases samples were taken directly from the source, but in others an intermediate storage container was used. In all cases, background samples for each run were collected at the same time and in the same manner as the filling of the bottles. Additionally, water turbidity measurements were taken before, during and after sample collection using a Hach^{\square} Pocket Turbidimeter (accurate to -1 NTU) to ensure that the water was clear enough for effective SODIS application.

4.1.1 Barasa

Barasa is located in the southeastern part of Haiti, near the border of the Dominican Republic. The elevation in Barasa is approximately 1,400 feet. This is a mountainous region, characterized by cooler temperatures but more intense solar radiation than Dumay. The daily weather conditions observed usually consisted of approximately half a day of full sunshine (though it varied between morning and afternoon hours) and half a day of partly cloudy or fully overcast skies. The average daily ambient air temperature peaked at about 28°C around 1pm, and radiation peaked at around 770 W/m² a 12:30pm (Figure 4.1).

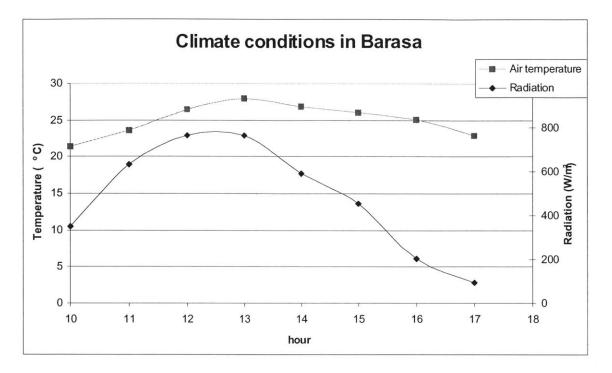


Figure 4.1 Average daily temperature and radiaiton profiles for Barasa

Barasa is located in a rural area where there is no access to running water or electricity. Therefore the people in Barasa do not have access to treated water, except for a few families with the Gift of Water, Inc. filtration system. Their main water supplies are cisterns or a nearby spring, Soos San Louis (Figure 4.2). This spring is difficult to access, not only because of its distance from the community, but also because it is located at the bottom of a steep ravine. The spring is highly contaminated, mainly from the fecal matter of pack animals used to transport water back to community members homes.



Figure 4.2 Pictures of Barasa community water source

Experiments in Barasa were carried out on the roof of the local school so as to avoid disruption by animals or children. The water used for this study was a combination of water from the spring and a nearby cistern. It was collected in large quantities approximately three times throughout the study and stored in large plastic tubs in an empty classroom of the school (Figure 4.3). The SODIS bottles were then filled using a spigoted bucket, following the shaking procedure recommended in Section 2.2.3 to ensure aeration. The average turbidity of the water was 5.8 NTU (Table 4.1), well below the 30 NTU recommended for SODIS to be effective. However, the turbidity peaked at 16.6 NTU on the third day of sample collection, possibly due to agitation of the water which resuspended settled particles, and would otherwise have been only 3.6 NTU.



Figure 4.3 Temporary water storage for experiments in Barasa

Run	0	1	2	3	Ave
1: 1/17	5-hour	3.5	3.5	4.1	3.7
1/18	1-&2-day	3.5	4.9	2.9	3.8
2: 1/20	5-hour	18.2	16.9	14.8	16.6
1/21	1-&2-day	3.6	6.4	4.5	4.8
3: 1/23	5-hour	0.6	0.3	8.6	3.2
1/24	1-&2-day	3.8	2.6	1.1	2.5
	5.8				
Av	3.6				

Table 4.1 WaterTurbidity Data for Barasa

4.1.2 Dumay

Dumay is located near the city of Port-au Prince, at the base of the southern claw of Haiti. Living conditions in Dumay are much better than in Barasa because of its proximity to the metropolis. Many homes have private wells or are connected to the public water supply. Additionally, treated water is released (on average three times) daily from public access facilities. Those who do not have access to these facilities collect water from local wells and streams.

Weather conditions are much hotter in Dumay because it is at a lower elevation (very near sea level) and does not benefit from the trade winds that cross the more mountainous regions. During the 5-hour duration of this experiment the sky was clear, there was little breeze, and sunlight was intense. The ambient air temperature peaked at 47°C at 1pm (Figure 4.2). Radiation measurements from this location are not available due to equipment difficulties, but have been assumed to be on the same order of magnitude of daily radiation in Barasa. Experiments were carried out on the roof of Pastor Nathan Dieudonne s house.

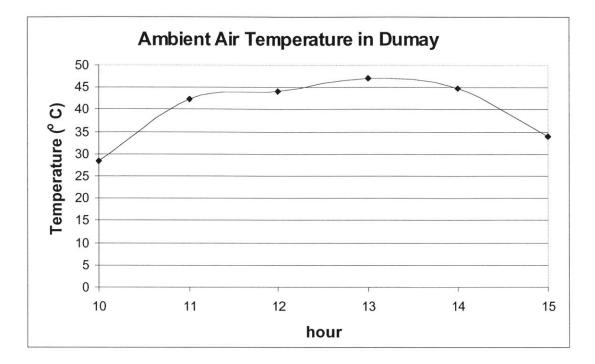


Figure 4.4 Ambient air temperature profile for Dumay

The water used for this study was collected directly from a local stream found running along the streets in a more rural section of the city. Downstream from the site of sample collection, women were found to be doing their laundry, implying that this is a common water source for the local community. Due to the number of poultry and other animals nearby, it can be inferred that fecal matter also contaminated the stream. The same aeration method as used in Barasa was applied during sample collection. The average turbidity of this source was 25.2 NTU, also below the 30 NTU threshold for effective SODIS application.

4.1.3 Boston

Boston is located at 42°N latitude, outside the recommended region for SODIS. Water supply and sanitation is not a problem in Boston, as it is an urban center of the developed world. Most residents have access to a reliable treated water supply or private wells. However, contamination is still a problem for area surface waters due to run off from streets, sewer overflows, and point sources. The source used for this experiment was the Charles River, which flows between the cities of Boston and Cambridge Massachusetts, and past the MIT campus where the experiments were conducted. Turbidity measurements are not available for this source because the equipment was not available. However, all samples did pass the SODIS water clarity test, described in Section 2.2.2.

The weather in Boston during the time of this study was typical for the winter season in the northern hemisphere. Cold (near freezing) temperatures were observed, peaking at 12° C around 2:30pm, and overcast skies limited available radiation to less than 400 W/m^2 . Because temperature and radiation measurements were taken less frequently than in Barasa, however, the exact peak radiation is not known (Figure 4.3). Additionally, because experiments were carried out on the roof of a four-story building, it was also subject to a constant breeze, which caused additional cooling of the bottles.

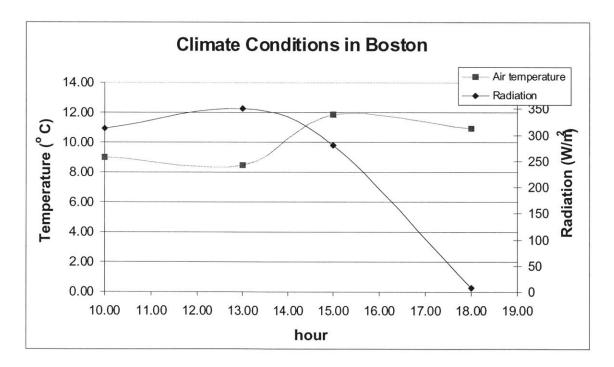


Figure 4.5 Average daily temperature and radiation profiles for Boston

4.2 Exposure and Monitoring

Nine different SODIS regimes (outlined in Table 4.2) were tested in Barasa. Duplicates were made of the bottles without a reflector and with the aluminum mylar reflector for quality control. Duplicates were not made of the bottles on the aluminum foil reflector due to lack of space. Each regime was tested over 5-hour, 1-day (7-8 hours), and 2-day (two 7-8 hour) exposure periods. Three complete sampling runs (including all regimes and exposure times) were completed, with the first day of the two-day exposure overlapping with the 1-day exposure (Figure 4.6).

 Table 4.2 Overview of experimental SODIS regimes and their purposes

	Regime	Data label	Purpose
Without Reflector	Clear bottle	C-a	UV
	¹ / ₂ black paint	C-b	UV and enhanced temperature
	Fully painted	C-c	Enhanced temperature
Reflector 1:	Clear bottle	UV1-a	Enhanced UV
Aluminum mylar	¹ / ₂ black paint	UV1-b	Enhanced UV and temperature
	Fully painted	UV1-c	Enhanced temperature
Reflector 2:	Clear bottle	UV2-a	Enhanced UV
Aluminum foil	¹ / ₂ black paint	UV2-b	Enhanced UV and temperature
	Fully painted	UV2-c	Enhanced temperature

January 2002						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
15	16	17	18	19	20	21
				5-hour	1-day	2-day (2)
					2-day (1)	,
					Run 1	
22	23	24	25	26	27	28
5-hour	1-day	2-day (2)	5-hour	1-day	2-day (2)	
	<u>2-day (1)</u>			<u>2-day (1)</u>		
	\sim					
	Run 2			Run 3		

Only the aluminum foil reflector was used in Boston and Dumay because observations made in Barasa determined there was no significant difference between it and the mylar reflector. Therefore, only seven exposure regimes were tested in Dumay and Boston. Additionally, duplicate bottles were not used, but duplicate microbial samples were taken instead. Only one 5-hour exposure regime was completed in Dumay. Two complete sampling runs, plus additional 1- and 2-day exposures were completed in Boston (Figure 4.7).

March 2002						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
					5-hour	1-day
					2-day (1)	2-day (2)
						Run 1
3	4	5	6	7	8	9
		5-hour	1-day	1-day	1-day	
		(1) (2-day (1)	2-day (2)	$\sqrt{2}$ -day (1)	2-day (2)	,
						ſ
			Run 2		Run 3	

Figure 4.7 Calendar of research in Boston

Temperature data was collected from every bottle hourly in Barasa and Dumay, and at least three times a day in Boston. A CheckTemp electronic thermometer from Hanna Instruments, which has an accuracy of $\pm 0.3^{\circ}$ C between -20 to 90° C, was used for making these measurements. In order to prevent cross contamination during this process, the thermometer was rinsed with boiled water between samples (see research plan in Appendix I.). Ambient air temperature was also recorded each time bottle water temperature measurements were taken.

Radiation data was collected hourly in Barasa using a Kipp & Zonen Solar Radiation Measurement System (Figure 4.8). This device measures total solar radiation between the wavelengths of 300 to 2800nm, which includes most UV-B, UV-A, visible, and some infrared radiation. The instrument detects both incoming direct solar radiation and reflected radiation. It works with a one percent accuracy between the temperatures of -40 to 80°C. Radiation data was not collected in Dumay due to equipment malfunction, and was collected with the same frequency as temperature data in Boston.



Figure 4.8 Kipp & Zonen Solar Radiation Measurement System

4.2.1 Microbial Analysis

In order to evaluate the effectiveness of each exposure regime, it is necessary to determine the amount of microbial inactivation achieved. In order to do this, both treated and untreated water samples were analyzed using the membrane filtration test methodology (Figure 4.9). In this test, a measured amount of water is passed through a membrane filter (pore size $0.45 \ \mu m$), which traps the bacteria contained in the sample on a paper filter (Maier, 2000). This filter is then placed on a thin absorbent pad in a petri dish saturated with a culture media specific to a desired indicator organism. The samples are then incubated at 35° C for 18-24 hours to stimulate growth of microbial colonies present.



Figure 4.9 Microanalysis equipment

The indicator organisms used in this study were *E.coli* and Total Coliforms. These bacteria normally occur in the intestines of warm-blooded animals and are thus a commonly used indicator of fecal contamination (Maier, 2000). These organisms are also generally hardier than disease causing bacteria, and therefore their absence is a reliable indicator of the absence of other organisms of real concern. Previous extensive research has shown that the absence of these organisms from 100mL of drinking water ensures the prevention of bacterial waterborne disease outbreaks. The culture media used was m-coli blue broth from Millipore Corporation, on which *E.coli* colonies grow blue and Total Coliform colonies grow red.

The exact process for the membrane filtration technique used in this study is outlined in the research plan in Appendix I. It was necessary to dilute samples with boiled water so that the number of colonies that grew was countable by hand. In Barasa, the first 5-hour run was uncountable because the samples were not diluted and therefore the plates were overgrown by Total Coliforms. Because the need to dilute samples was not anticipated, proper measuring devices were not available. Therefore, the 10mL dilution used in Barasa was estimated as halfway to the 20mL mark on the filtration cup. In both Dumay and Boston, the 20mL mark on the sample filtration cup was used, and is therefore more accurate. However, it is not anticipated that any inaccuracies in dilution will have a large effect on calculations because of the order of magnitude differences between samples being compared.

Blanks were run for quality control purposes using sterile water and the boiled water used for dilution. The plates were incubated for 24 hours in a phase change incubator, provided by Amy Smith of the MIT Edgerton Center. This incubator does not require electricity, but instead maintains a constant temperature by taking advantage of the phase-change behavior of a material whose melting point is at the incubation temperature required. Once the material is melted, it keeps a constant temperature until it completely solidifies again (Smith, 2002). Therefore, the only energy input necessary to use this incubator was the heat necessary to initially melt the material — which was done by warming it in a pot of boiling water (see instructions for use in Appendix I). After 24

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hours of incubation, the *E.coli* and Total Coliform colonies on each plate were counted and normalized to a 100mL sample by multiplying by the dilution factor. The membrane filtration technique gives a measure of the absolute number of bacteria present in the sample, so that the percent kill for each regime could then be calculated.

5 Results

5.1 Bottle Water Temperature

The bottle water temperature for the different regimes and different locations varied greatly because of the thermal enhancement techniques used and the local weather conditions. However, consistent trends with the time of day were observed within the same regime at the same location over different length exposure periods. Therefore, in order to provide a more representative profile of the average bottle water temperature, the data from all exposures (5-hour, 1-day, 2-day (day 1), and 2-day (day 2)) were combined. Individual daily data and data summaries are provided in Appendix II. Following are the resulting temperature profiles for each location in which the study was conducted.

5.1.1 Barasa

Bottle Water temperatures in Barasa did not ever exceed the threshold of 50°C required for significant thermal disinfection. The temperatures of the bottles on either reflector were not significantly different (i.e. the standard deviation was less than the accuracy of the thermometer) from their counterparts without a reflector. Therefore, the temperature profiles of all three regimes (and duplicate bottles) were averaged in creating the average daily temperature profile (Figure 5.1).

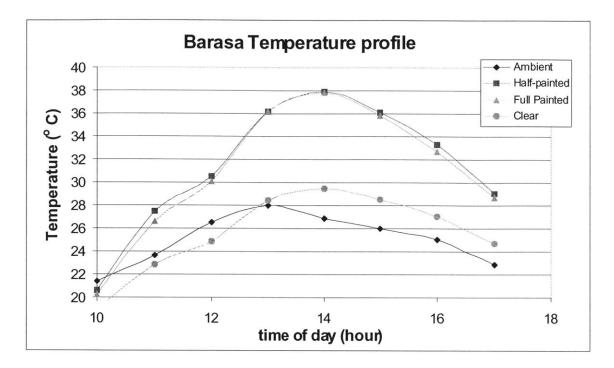


Figure 5.1 Bottle water temperature profile for Barasa

As illustrated in Figure 5.1, the temperature profile of the half-painted bottles was very similar to that of the fully painted bottles. The bottle water temperature in the clear bottle peaked at around 30°C, which is not significantly warmer than the ambient air temperature. The bottle water temperature of both the half-painted and fully painted bottles peaked around 38°C, approximately 10°C higher than the ambient air temperature. Therefore, a temperature increase of 8°C was achieved by painting the bottles — 3°C more than indicated in the literature. All of the bottles reached their peak temperatures approximately one hour later than the peak ambient air temperature and radiation.

5.1.2 Dumay

The SODIS experiments carried out in Dumay reached much higher temperatures than those in Barasa. This can be attributed to the much warmer and calmer weather conditions observed in Dumay. However, because only one 5-hour experiment was carried out in Dumay, the data is much less representative than that collected in Barasa. As in Barasa, the water temperature of bottles on the reflector were not significantly different from their counterparts, and therefore these data were grouped in creating the temperature profile for each regime (Figure 5.2).

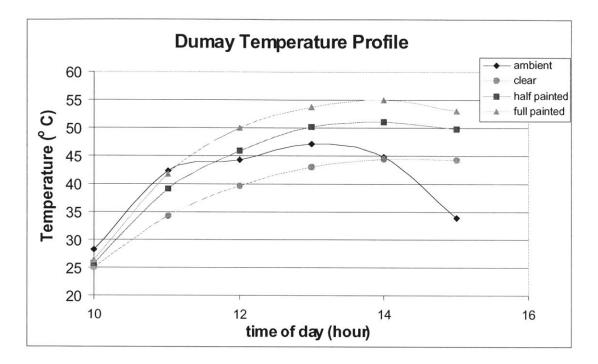


Figure 5.2 Bottle water temperature profile for Dumay

Unlike in Barasa, in Dumay both the painted and half-painted bottle water temperatures exceeded the threshold temperatures necessary for pasteurization for at least one hour. The peak temperature in the clear bottle was 44.5°C, also high enough to induce synergistic thermal effects. The peak temperature reached in the fully painted bottle was 55°C and in the half painted bottle it was 51°C. This is therefore an increase of approximately 10°C for the fully painted bottle and 6°C for the half painted bottle. Interestingly, the clear bottle water peak temperature was cooler than that of the ambient air temperature of 47°C. All peak bottle water temperatures were all reached approximately one hour later than the peak ambient air temperature.

5.1.3 Boston

Temperatures in Boston were significantly cooler than those in either Barasa or Dumay because of its northern latitude and the time of year. Additionally, temperature was not monitored as regularly as at the other sites, and thus the profile is less defined. Again, there was no significant difference in temperature between the bottles on the reflector and those without and so these data were combined to create a more representative profile. The clear bottles appeared to peak at 11°C (Figure 5.3). As in Barasa, the painted and half-painted bottles had very similar temperature profiles, and both peaked at 14°C, three degrees warmer than the clear bottle, which is not a significant difference given the accuracy of the equipment.

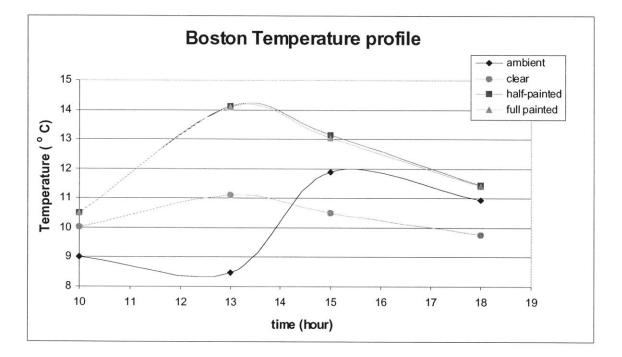


Figure 5.3 Bottle water temperature profile for Boston

5.1.4 Summary

Overall, given sufficient climate conditions, painting the bottles was effective for raising the bottle water temperature in this study. Additionally, the amount the temperature was raised as compared to the clear bottles was greater than was indicated in the literature (which is likely a conservative estimate). The results are inconclusive on the effectiveness of painting the bottles half black versus fully black, for in Dumay the

temperature increase was different between the two, whereas in Barasa they were very similar.

However, in Barasa the temperature increase in the half and fully painted bottles was not sufficient to induce either synergistic effects or pasteurization. The main difference in climate conditions between Barasa and Dumay was the ambient air temperature and wind speed. It can be assumed that the amount of available solar radiation was the same order of magnitude, though measurements for Dumay are not available. If anything, solar radiation would have been more abundant in Barasa because of its higher elevation. Additionally, the temperature profile for Dumay is less complete than that for Barasa, and thus less reliable.

5.2 Microbial inactivation

Unlike the bottle water temperature, the amount of microbial inactivation observed in each regime varied more with the amount of exposure than the location. Thus, data from the multiple runs of each exposure length in each location were grouped in order to provide a more representative data set. Individual data from each run, as well as data summaries, are provided in Appendix II along with the bottle water temperature data.

The amount of microbial kill (N_k) was calculated by subtracting the number of colonies present in the bottle sample (N_s) from the number in the background sample (N_b) collected at the same time (Equation 8). This number was the divided by the background number, and multiplied by 100 for the percent kill (P_k) (Equation 9).

$$N_{k} = N_{b} - N_{s}$$
(Equation 8)
$$P_{k} = (N_{k} / N_{b})^{*} 100$$
(Equation 9)

In some samples the plates were too overgrown to count individual colonies and were therefore labeled Too Numerous to Count . Therefore, in calculating the percent kill for these samples, the largest number of colonies that was counted for a treated water sample during that run was used in substitution for N_s .

5.2.1 Barasa

The amount of microbial inactivation observed in Barasa varied not only with the exposure regime used, but also with the length of exposure. With 5 hours of exposure 100 percent kill was observed for *E.coli* in the clear bottle regimes on reflectors (UV1-a and UV2-a) (Figure 5.4). Additionally, 96 percent kill for *E.coli* was observed for the clear bottle not on a reflector (C-a). Significant kill was also observed for Total Coliforms in all clear bottle regimes. Additionally, some kill of Total Coliforms was observed in the half painted bottles (C-b, UV1-b and UV2-b). However, it appeared that there was growth of *E.coli* in these bottles, as indicated by negative percent kill, as well as all fully painted bottles (C-c, UV1-c and UV2-c).

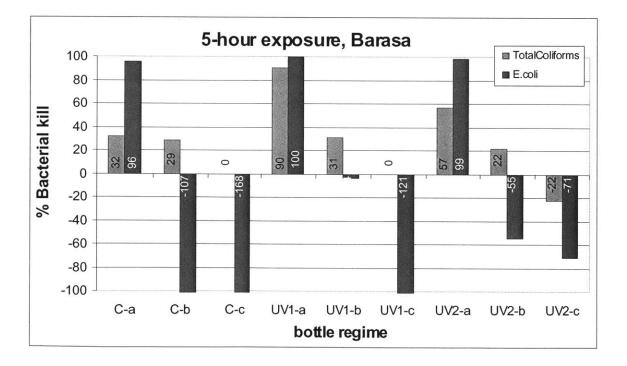


Figure 5.4 Percent bacteria kill after 5-hours exposure in Barasa

For 1-day of exposure, approximately 100 percent kill for *E.coli* was observed in all clear and half-painted bottle regimes (Figure 5.5). For Total Coliforms, almost 100 percent (approximately 96 percent) kill was observed in the clear bottles, and significant kill was observed in the half painted bottles. No significant kill was observed in the fully painted bottles, in fact *E.coli* growth was again apparent.

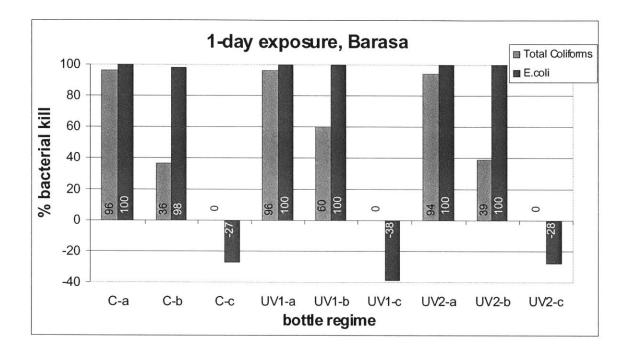


Figure 5.5 Percent bacteria kill after 1-day exposure in Barasa

With 2-days of exposure, 100 percent kill for *E.coli* was observed in all clear and half-painted bottles (Figure 5.6). Over 80 percent kill for Total Coliforms was also observed in all these bottles. While significant kill for *E.coli* was apparent in the fully painted bottles as well, it was much less significant than for Total Coliforms.

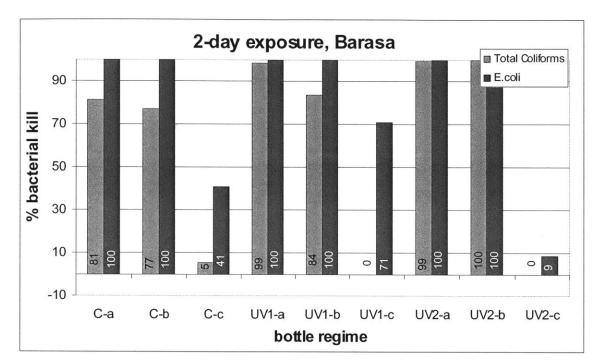


Figure 5.6 Percent bacteria kill after 2-days exposure in Barasa

5.2.2 Dumay

The amount of kill observed after 5-hours of exposure in Dumay was much higher than that observed in Barasa. Greater than 90 percent kill was observed for *E.coli* in all bottle regimes, reaching 100 percent in all bottles on the reflector and the half painted bottle not on the reflector (Figure 5.7). For Total Coliforms, kill greater than 80 percent was observed in the half painted and fully painted bottle not on the reflector and the half painted bottle on the reflector. Total Coliform kill was also observed in the clear and half painted bottles on the reflector. One and two day tests were not conducted in Dumay.

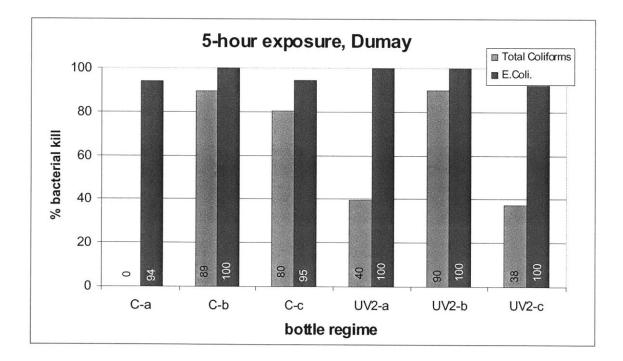


Figure 5.7 Percent bacteria kill after 5-hours exposure in Dumay

5.2.3 Boston

In Boston, 100 percent kill of *E.coli* was observed in all clear and half-painted bottles after the 5-hour exposure (Figure 5.8). Over 80 percent kill for Total Coliforms was also observed in these bottles. Significant kill was also apparent for *E.coli* in the fully painted bottles, but there actually appeared to be growth of Total Coliforms, the opposite of what was observed in Barasa.

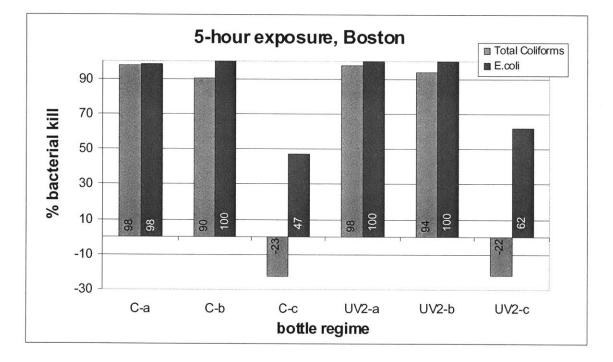


Figure 5.8 Percent bacteria kill after 5-hours exposure in Boston

After 1-day exposure, 100 percent *E.coli* kill was observed in both clear bottles and over 90 percent kill was observed in the half-painted bottles (Figure 5.9). For Total Coliforms, the percent kill in the clear bottles was 80 percent, and around 75 percent in the half-painted bottles. Significant *E.coli* kill was also observed in the fully painted bottles.

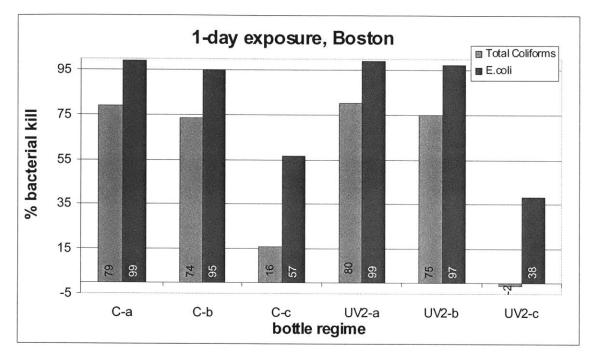


Figure 5.9 Percent bacteria kill after 1-day exposure in Boston

For 2-days of exposure, 100 percent kill was observed for *E.coli* in both the clear and half-painted bottles (Figure 5.10). Additionally, kill greater than 95 percent for Total Coliforms was also observed in these bottles. Significant kill was observed for *E.coli* in the fully painted bottle without a reflector, but growth of both *E.coli* and Total Coliforms was actually apparent in the fully painted bottle on the reflector.

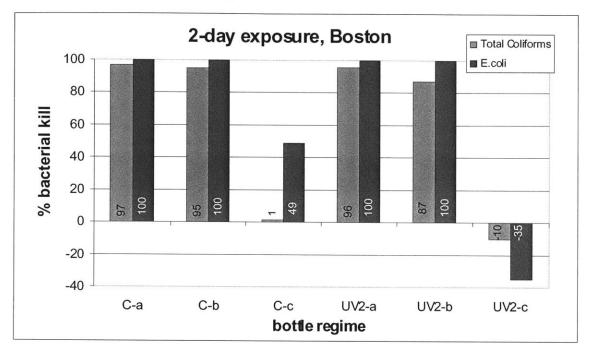


Figure 5.10 Percent bacteria kill after 2-day exposure in Boston

5.2.4 Summary

Overall, the effectiveness of each exposure regime was related to the length of the exposure time and location. The clear bottle regimes, both with and without a reflector, were most effective. Approximately 100 percent *E.coli* inactivation in all locations regardless of the duration of the exposure was seen in this regime. Additionally, the half painted bottle regimes consistently showed significant *E.coli* inactivation as well, though the percent inactivation increased with exposure time. The fully painted bottle regimes were generally not effective, except in Dumay.

5.3 Evaluation of Results

5.3.1 Barasa

The conditions observed in Barasa were sub-optimal for SODIS application because of cool climate conditions, but abundant solar radiation was available. None of the bottle water temperatures reached 50°C necessary for thermal disinfection (Figure 5.11). However, as shown in Figure 5.11, solar radiation was abundant in Barasa, and exceeded the necessary 500 W/m2 for effective UV-related microbial inactivation. This would therefore account for the differences in kill observed in the clear and half-painted bottles, which were exposed to UV radiation, versus the fully painted bottles, which were not exposed to UV radiation.

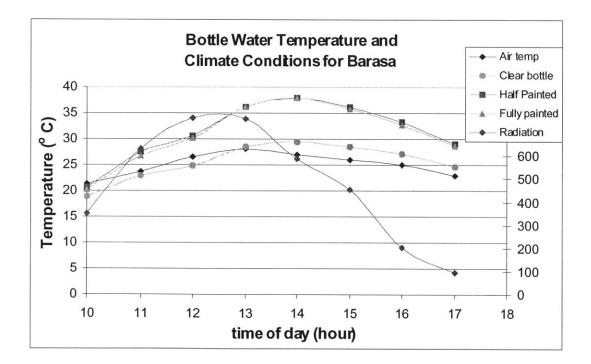


Figure 5.11 Bottle water temperature and climate conditions in Barasa

5.3.2 Dumay

The conditions in Dumay were ideal for the application of SODIS because not only was there abundant solar radiation, but the climate was warm as well. Both the halfpainted and fully painted bottles exceeded the threshold temperature of 50°C for the onehour required. It is therefore not surprising that significant kill was observed in both of these bottles. Additionally, it can be assumed that the amount of available solar radiation was high, therefore also effecting significant kill in the clear bottle as well.

5.3.3 Boston

The conditions in both Boston were again sub-optimal for SODIS application because of limited solar radiation and extremely cold temperatures. However, the trend in microbial inactivation was similar to that observed in Barasa. Significant kill was observed in the clear and half painted bottles, regardless of exposure time, implying that solar radiation was sufficient for bacterial deactivation, whereas there was no significant kill in the fully painted bottles.

5.4 Statistical analysis

In order to properly analyze the effectiveness of the different exposure regimes, two different statistical tests were used to detect trends in the data. The two tests used were the Mann-Whitney test and the 2-sample t-test. Both of these tests compute and compare the means of two sample sets and use the sample variances to determine whether or not they are statistically different within a given confidence interval. If the means of the two samples are statistically different, then it is assumed the two sample sets are statistically different within the same confidence interval.

Ideally these tests are applied to large sample sets, which are more representative of actual conditions. Unfortunately, the amount of data collected in this study was limited (only 2 data points for each exposure regime per run, therefore 6 total data points per location for each exposure regime). Because the conditions in Boston and Barasa were similar in that they did not exceed the threshold temperature, the two data sets were analyzed individually and grouped. No statistical analysis was conducted on the data collected in Dumay. Statistical analysis was used to evaluate a number of different parameters and determine which regimes were worthy of further investigation. Each test compares two sample sets. The first analysis compared the background microbial concentrations to the concentrations in the treated water of each regime. The purpose of this analysis was to determine if the amount of bacterial kill in each regime was in fact significant, and thus the regime could be considered effective for water treatment. The second analysis compared the clear and half-painted bottle regimes on the two reflectors to their counterparts without a reflector. This analysis was used to determine whether or not the reflector was effective in enhancing microbial deactivation. Finally, the clear and half painted bottle regimes on the two different reflectors were compared in order to determine if there was a significant difference in their effectiveness.

5.4.1 Evaluating the Effectiveness of Each Regime

With 5-hours of exposure, only the microbial concentrations in the clear bottle regimes (both with and without the reflector) and the half-painted bottle regime on the aluminum foil reflector were statistically different from the background microbial concentration within a 95 percent confidence interval. Therefore, it can be assumed that these regimes were effective for microbial deactivation with only 5-hours of exposure. However, all of the other half-painted bottle regimes were statistically different from the background microbial concentrations within an 80 percent confidence interval, and thus could also be considered effective exposure regimes, though less so than the others mentioned. None of the fully painted bottle regimes in Boston or Barasa had statistically significant microbial deactivation.

	Statistically significant microbial kill?		
	Yes		No
	95% confidence interval	80 % confidence interval	
No reflector			
Clear bottle	\checkmark		
Half-painted bottle	· · · · · · · · · · · · · · · · · · ·	\checkmark	
Painted bottle			\checkmark
Al mylar reflector			
Clear bottle	\checkmark		
Half-painted bottle		\checkmark	
Painted bottle			\checkmark
Al foil reflector			
Clear bottle	\checkmark		
Half-painted bottle	\checkmark		
Painted bottle	· · · · · · · · · · · · · · · · · · ·		\checkmark

Table 5.1 Statistically significant microbial kill after 5-hour exposure

With 1-day of exposure, both the clear bottle regimes (with and without the reflector) and the half-painted bottle regimes on either reflector were statistically different from the background microbial concentration within a 95 percent confidence interval. Thus, with 1-day of exposure these bottle regimes were effective for microbial deactivation. The half-painted bottle regime not on a reflector was also statistically different from the background microbial concentrations, but only within a 90 percent confidence interval, meaning it is also effective for microbial deactivation. Again, the fully painted bottles did not have statistically significant microbial deactivation.

	Statistically significant microbial kill?		
	Yes (95% confidence interval)	No	
No reflector			
Clear bottle	\checkmark		
Half-painted bottle	\checkmark		
Painted bottle		\checkmark	
Al mylar reflector			
Clear bottle	\checkmark		
Half-painted bottle	\checkmark		
Painted bottle		\checkmark	
Al foil reflector			
Clear bottle	\checkmark		
Half-painted bottle	\checkmark		
Painted bottle		\checkmark	

Table 5.2 Statistically significant microbial kill after 1-day exposure

For 2-days of exposure, all clear and half-painted bottle regimes had statistically different microbial concentrations from the background samples, within a 95 percent confidence. Therefore, all these regimes were equally effective for microbial inactivation. The analysis determined that the microbial concentrations in the fully painted bottles were not statistically different form the background concentrations, and thus they were not effective for microbial inactivation.

	Statistically significant microbial kill?		
	Yes (95% confidence interval)	No	
No reflector			
Clear bottle	\checkmark	ta na anna anna anna anna anna anna ann	
Half-painted bottle	\checkmark		
Painted bottle		\checkmark	
Al mylar reflector		and the life of the second sec	
Clear bottle	\checkmark	<u>-</u>	
Half-painted bottle	\checkmark		
Painted bottle		\checkmark	
Al foil reflector			
Clear bottle	\checkmark		
Half-painted bottle	\checkmark	. Men entre	
Painted bottle		\checkmark	

Table 5.3 Statistically significant microbial kill after 2-day exposure

Overall, only the clear bottle regimes were consistently effective for microbial inactivation, regardless of exposure time (within those investigated). However, the effectiveness of the half painted bottle regimes seems to increase with exposure time, and it also seems to be enhanced by use of the solar reflectors. Additionally, because the bottle water temperatures in Boston and Barasa did not reach those necessary to either induce synergistic effects or thermal inactivation, it is possible that the half painted bottle regimes would be more effective in only slightly warmer climates. The fully painted bottles were not effective in either Boston or Barasa because threshold temperature for thermal inactivation was not reached and no UV effects could penetrate the system.

5.4.2 Evaluating the Use of Solar Reflectors

Data was collected daily in Barasa to compare the amount of radiation incident on a bottle on and off a reflector. Calculations made from these measurements show that the aluminum mylar reflector increased the apparent sunlight intensity an average of 20 percent. According to the above evaluation, it appears that the reflectors do in fact enhance the effectiveness of microbial inactivation in the half painted bottles. However, statistical analysis shows that the microbial concentrations in the clear and half painted bottle regimes are not statistically different between the bottles on the reflector and not, within a 95 percent confidence interval. This analysis was conducted for each of the 5hour, 1-day, and 2-day exposure data sets within the grouped Boston and Barasa data, as well as the two individual location data. Additionally, no statistical difference was detected between the microbial concentrations in the bottles on the two different reflectors.

5.4.3 Summary

The validity of this statistical analysis is questionable because the sample set is small and may not be truly representative of the effectiveness of the bottle regimes. Additionally, the data that was collected contained many samples that had 100 percent kill. The presence of these zeros and the lack of a normal distribution of the data greatly skew the mean of the data set. Additional research is necessary to supplement this data for proper statistical analysis.

While few conclusions can be drawn from the data available about the effectiveness of the different exposure regimes, it is fairly clear which ones are worthy of further research. Because the bottle water temperatures of the fully painted bottles was not significantly different from that of the half painted bottles, and because there was no significant microbial inactivation in the fully painted bottles, they are not worth further research. The same temperature gains can be achieved in the half painted bottles, while still allowing for UV effects.

The clear and half-painted bottle regimes are worthy of further investigation specifically on their effectiveness in non-tropical climates. In particular, because the clear bottle regimes were consistently effective with only 5-hours of exposure, their effectiveness with shorter exposure times and/or less intense radiation should be investigated. Additionally, the same variable seemed to affect the effectiveness of the half-painted bottle regimes. However, because there is an abundance of data on the effectiveness of these two regimes in other locations already, more worthy of further study is the use of solar reflectors to enhance their effectiveness. In investigating the use of these reflectors, not only should the conditions of this study be repeated, but also additional exposure times and sunlight intensities.

5.5 Bottle Water Temperature Model

The bottle water temperature model developed as a part of this study was created using a Microsoft Excel spreadsheet (presented in Appendix III). The average air temperature and radiation data collected in Barasa were used as the climatic inputs to the model, and so the outputs were compared to the actual bottle water temperature monitored in Barasa. However, the one-hour time step at which measurements were taken was found to be too large to achieve accurate calculations with the model, and so the data was interpolated at 10 minute time steps. Because the wind speed and direction was not monitored in Barasa, the speed was estimated to be approximately 3.8m/s from observations using the Beaufort scale (Table 5.1). It was assumed that the wind direction was perpendicular to the bottles, which would thus overestimate the amount of convection occurring.

Beaufort #	General description	Specifications	Wind speed (m/s)
0	Calm	Smoke rises vertically	Under 0.6
1	Light air	Wind direction shown by smoke drift but not by vanes	0.6-1.7
2	Slight breeze	Wind felt on face; leaves rustle; ordinary vane moved by wind	1.8-3.3
3	Gentle Breeze	Leaves and twigs in constant motion; wind extends light flag	3.4-5.2
4	Moderate Breeze	Dust, loose paper, and small branches are moved	5.3-7.4
5	Fresh breeze	Small trees in leaf begin to sway	7.5-9.8
6	Strong breeze	Large branches in motion; whistling in telephone wires	9.9-12.4
7	Moderate gale	Whole trees in motion	12.5-15.2
8	Fresh gale	Twigs broken off trees; progress generally impeded	15.3-18.2
9	Strong gale	Slight structural damage occurs; chimney pots removed	18.3-21.5
10	Whole gale	Trees uprooted; considerable structural damage	21.6-25.4
11	Storm	Widespread damage	25.5-29.0
12	Hurricane		Above 29.0

 Table 5.4 Beaufort Scale (Petterssen, 1969)

The short-wave transmissivity of the plastic was calculated from measurements taken in Barasa by placing the end of a plastic bottle around the pyranometer. The meter therefore gave a measure of the percent of radiation that was not reflected or absorbed by the bottle. The painted plastic was completely opaque, but the clear plastic transmitted approximately 90 percent of the radiation. Additionally, measurements were taken to calculate the percent attenuation of radiation through the bottle, which was found to be 80 percent of the total radiation (i.e. only 20 percent of the radiation was transmitted through the full bottle of water). The plastic s transmissivity/emissivity of long-wave radiation could not be calculated because there was no way to measure this radiation. The thermal conductivity of the plastic was found to be 0.2 W/mK (Matweb, 2002).

In general, convection was the limiting term to heat transfer in this model. Because convection is small, the surface temperature built up so that it was very close to the bottle water temperature, therefore limiting the rate of conduction, and creating an insulating effect. Additionally, because the long-wave properties of the plastic are unknown, the model was run both with and without these components (Figures 5.12-14). Neglecting long-wave radiation creates a better fit for the clear bottle model, but has little effect on the fit of the half-painted and fully-painted bottle models.

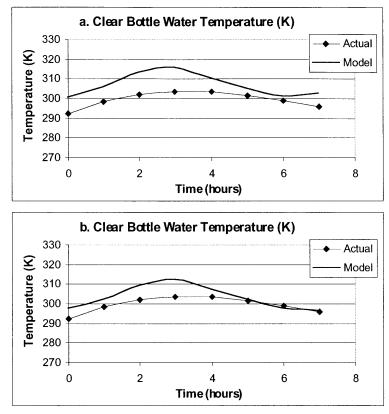
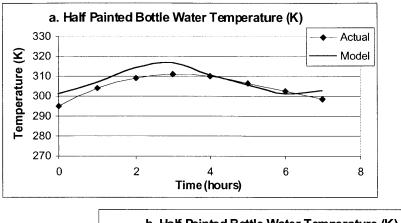
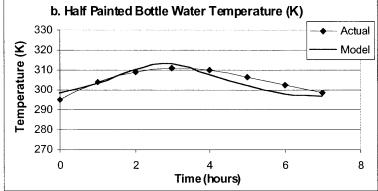
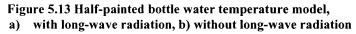
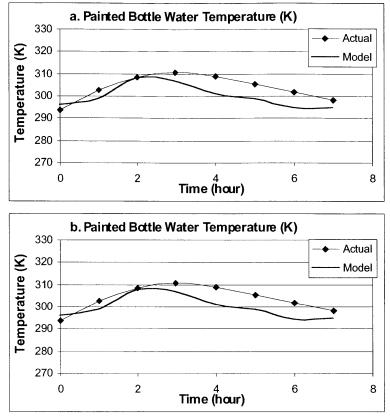


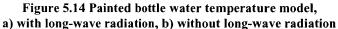
Figure 5. 12 Clear bottle water temperature model, a) with long-wave radiation, b) without radiation











As illustrated in Figures 5.12, the model consistently overestimates the temperature. However, an underestimate of the bottle water temperature would be more acceptable for SODIS application. Modifying the transmissivity factors for the clear bottle can greatly improve the fit, but it is consistently too high, even when all short-wave radiation is ignored. Additionally, there is no logical basis for this change. It is believed that theses discrepancies are more likely caused by inaccuracies of the material properties than by oversight of additional heat components. Therefore, more research is needed to assess the actual reflective, transmissive, and emissive properties of the plastic in order to make the model more accurate.

6 Conclusions

6.1 Thermal Enhancement

In order for thermal inactivation alone to be effective for microbial deactivation in the SODIS system, a bottle water temperature of 50° C must be exceeded for at least one hour. Additionally, reaching this temperature also causes synergistic effects between UV and temperature to be enabled. It has been shown that painting the bottom half of the bottles black can raise the water temperature 5° C, depending on the amount of radiation available. In order to test this technique under sub-optimal SODIS conditions, bottles in this study were painted half black so that UV inactivation of bacteria could also take place within the bottle. Additional bottles were fully painted in hopes of absorbing more radiation than the half painted bottles and thus raising the temperature more.

Under sub-optimal conditions, there was no significant difference in the amount the bottle water temperature was raised in the half-painted or fully painted bottles. The bottle water temperature of the clear bottles was the same as that of the ambient air temperature. In Barasa, the peak temperature difference between the clear and painted bottles was 8°C — greater than that expected from the literature. However, this only achieved a peak bottle water temperature of 38°C, well below the thresholds mentioned above. In Dumay however, which has similar amounts of available solar radiation, a temperature difference of almost 10°C was achieved, and the threshold temperature of 50°C was exceeded in both painted bottles. The difference in the peak temperature achieved can be mainly attributed to the difference in weather conditions, which were cooler and breezier in Barasa, which would cause cooler bottle water temperatures.

In order to assess whether or not a thermal enhancement technique would be effective in a specific region, the local weather conditions (air temperature, wind, available solar radiation) must be known. In general, if the ambient air temperature does not reach 45° C, it can be assumed that the painted bottle water temperature will not reach 50° C. Additionally, because there was little difference in temperature between the half-

painted and fully painted bottle, bottles should only be half painted in order to also allow for synergistic effects with UV.

6.2 UV enhancement

The second active disinfection mechanism of SODIS is UV induced DNA alterations, which inhibits proper cellular replication. According to SANDEC News, No. 3, a total sunlight intensity of 555 W/m² is necessary to induce these lethal UV effects. In order to increase the sunlight intensity in the system, a reflector was built to gather sunlight from a wider area and focused it on the SODIS bottles. This would not only enhance the UV intensity in the system, but also had the potential to additionally increase the bottle water temperature through increased radiation absorption. Two different reflective materials were used: aluminum mylar and aluminum foil. Aluminum mylar is sturdy and highly reflective, but aluminum foil has similar properties, and is also more commonly available in the developing world. The aluminum mylar reflector increased the apparent sunlight intensity an average of 20 percent. However, the amount of microbial kill observed in bottles on either reflector was not statistically different from that of their counterparts not on a reflector, nor was there a significant difference in bottle water temperature.

There are many reasons why the reflector may not have had a significant impact on microbial kill. First of all, the dimensions of the reflector were not optimized to the bottle size because the bottle size to be used in different locations was not known. Additionally, because of material lightness, it was easily misshapen by the wind, often causing partial shading of the bottles. Finally, the amount of ambient solar radiation may have been abundant enough that a 20 percent increase (i.e. 1100 W/m² versus 900 W/m²) did not have significant effect. These results are not consistent with the findings of Kehoe, *et al* (2001), who observed a significant increase in solar intensities and water temperature, resulting in an increased inactivation rate. However, the efficiency of reflective backing may be higher than that of the reflectors used in this study, thus accounting for the difference in results. Additionally, the Kehoe, *et al* study was

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conducted using laboratory simulated solar radiation, which would thus be more evenly distributed than natural sunlight.

Further studies are needed in order to properly evaluate the effective use of solar reflectors/reflective bottle backing. Possibly such enhancement techniques would be more obviously effective with shorter exposure times or lesser amounts of ambient solar radiation. In any case, the reflectors did not seem to inhibit microbial deactivation and when used properly can be used without concern of negative impacts on the system.

6.3 Summary

Proper assessment of the possible application of SODIS to a region is dependent on a number of factors. Therefore, it is strongly recommended that proper field studies be completed before SODIS is introduced as the primary point-of-use water treatment system in that area. However, in order to make most efficient use of field study time, the following should be noted about thermal enhancement using black paint:

- There was no significant difference in the bottle water temperatures on the fully painted bottles versus the half painted bottles. Therefore, bottles should only be half painted (if at all) so as to allow for synergistic effects with UV as well.
- In order for bottle water temperatures in a half painted bottles to reach temperatures of 50°C necessary to activate synergistic effects, ambient air temperatures need to reach at least 45°C.

If condition (2) is met, than only one hour of exposure is necessary. However, if (2) cannot be achieved, then the bottles should not be painted. In this case, a reflective surface (such as a reflector or reflective bottle backing) may be more effective in achieving increased deactivation by increasing sunlight intensity focused on the bottles. This study evaluated a number of different exposure regimes in non-tropical climates in order to determine which were most effective and worthy of further research. In general, the fully painted bottle regimes were not significantly more effective for reaching the required temperatures than the half painted bottles. Additionally, there have been numerous studies already conducted on the use of the clear and half painted bottle regimes without a reflector. Therefore, it is recommended that the primary focus of future studies focus on the use of such reflectors with the clear and half painted bottle regimes in non-tropical climates.

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APPENDIX I: Research plan

SODIS Research Plan for Haiti, January 2002

Massachusetts Institute of Technology Researcher: Julia Parsons Advisor: Daniele Lantagne

Overview

One entire experiment should take 4 days, from initial sample collection to final microbial analysis. It will consist of 3 complete sample runs consisting of 17 bottles, 2 background samples and 2 blanks (21 samples total). The experiment will be run at least 3 times throughout our 15-day stay in Barasa.

Bottle Regimes:

Regime	Label	
No reflector	clear (2)	C-a1 and C-a2
	1/2 black (2)	C-b2 and C-b2
	all black (2)	C-c1 and C-c2
Al Mylar reflector:	clear (2)	UV1-a1 and UV1-a2
•	¹ / ₂ black (2)	UV1-b1 and UV1-b2
	all black (2)	UV1-c1 and UV1-c2
Al foil reflector	clear (1)	UV2-a
	$\frac{1}{2}$ black (1)	UV2-b
	all black (1)	UV2-c

All supplies will be brought to Haiti from Boston, with the exception of bottles and paint. A detailed schedule, instructions for sample collection, exposure and membrane filtration follow.

The same procedures will be used for sampling done in Dumay and Boston as well.

Schedule

Day 1: Site selection, Bottle selection and preparation, Equipment preparation

Run #1 Day 2: SC1a EXP1a (5 hours) MF1a*, begin I1a* Day 3: SC1b&c EXP1b&c (1 day, 2 day - day1)MF1b*, begin I1b* continue I1a, CC1a* Day 4: continue EXP1c (day 2) MF1c*, begin I1c continue I1b, CC1b* Day 5: continue IIc, CC1c*

Run #3 Day 8: SC3a, EXP3a (5 hours) MF3a*, begin I3a* Day 9: SC3b&c EXP3b&c (1 day, 2 day - day1)MF3b*, begin I3b* continue I3a, CC3a* Day 10: continue EXP3c (day 2), MF3c*, begin I3c continue I3b, CC3b* Day 11: continue I3c, CC3c*

Run #2

Day 5: SC2a, EXP2a (5 hours) MF2a*, begin I2a* Day 6: SC2b&c EXP2b&c (1 day, 2 day - day1) MF2b*, begin I2b* continue I2a, CC2a* Day 7: continue EXP2c (day 2) MF2c*, begin I2c continue I2b, CC2b*

Day 8: continue I2c, CC2c*

(SC = sample collection, EXP = exposure, MF = membrane filtration, I = incubation, CC = colony counting, a = 5 hr exposure, b = 1 day exposure, c = 2 day exposure) * in evening

Bottle Selection and Preparation

Equipment:

Towel	Soap
Wash basin	Turpentine
Black paint	Paintbrush
Labeling marker	Aluminum foil and tape
Drying rack	Bottle Condition data sheet
Newspaper	Sponge and Bottlebrush

Preparation:

- Collect Bottles that meet the following specifications:
 1 liter w/ lid, minimal scratches, dents and deformations
- 2) Make note of original condition on data sheet (ie. clear, minimal scratches, excessive scratches, deformation, discoloration). Expand on condition in "Notes" section at bottom of page if necessary.
- 3) Wash bottles using boiled water and non-disinfectant soap. Clean inside by vigorous shaking (use bottlebrush only if necessary – it scratches) and outside using soft sponge. Be careful not to scratch bottle or remove paint.

NOTE: if new, unopened bottles are bought from a store, there is no need to wash them because them have been sterilized by the packaging process.

** DO NOT use chemically treated (ie. chlorinated) water or other kind of disinfectant on the bottles at ANY TIME. Using alcohol will increase kill and cause lower apparent microbial concentrations**

- 4) Dry outside with towel/paper towels and place on end in drying rack
- 5) Prepare bottles as follows:
 6 fully painted black, 6 ¹/₂ black, 6 clear
- 6) *Paint:* Line edges of surface to be painted with tape. Paint with paintbrush, being careful not to drip paint on surface that should not be painted. Allow paint to dry by placing on end in drying rack, over newspaper. Coat with additionally layers until opaque (test opaqueness by holding up to light).
- 7) Label lids as shown above.

SODIS Bottle Condition - Haiti, January 2002

Run#:

Dates:

		Day		la day 1	2 day -2
Bottle	original condition	5 hr	1 day	2 day -1	2 uay -2
C-a1					
C-a2					
C-b1					
C-b2					
C-c1					·····
C-c2					
C-d1					
C-d2					
UV1-a1					
UV1-a2					
UV1-b1					
UV1-b2					
UV1-c1					
UV1-c2					
UV2-a					
UV2-a2					
UV2-b					
UV2-b2					
UV2-c					
UV2-c2	2				

Collecting Water samples

Equipment:

Whirlpack bags Labeling Marker Thermometer Turbidimeter Bottles Turbidity/Radiation data sheet Bottle Condition data sheet Bottle Temperature data sheet

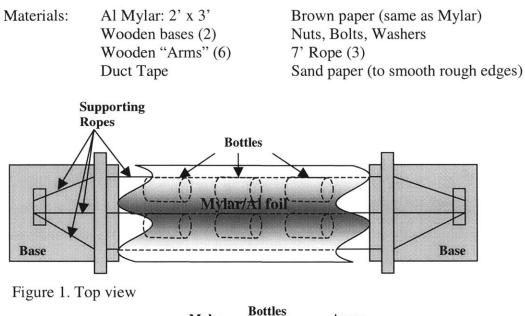
Procedure:

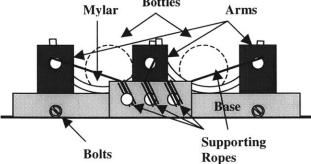
- 1) Note condition of each bottle for appropriate day on data sheet (ie. clear, minimal scratches, excessive scratches, deformation, discoloration). Expand on condition in "Notes" section at bottom of page if necessary.
- 2) Take all bottles (plus extra) and 4 whirlpack bags to source as early in the day as possible so as to maximize exposure time.
- 3) Take initial turbidity reading using turbidimeter. Record on Turbidity/Radiation data sheet.
- Collect first background sample in a whirlpack bag: Label sample bag. Rip off top, open using tabs and be sure bottom is open. Fill to line and whirl closed. Wipe down outer surface and set aside.
- 5) Rinse inside of bottle with sample water by partially filling & shaking vigorously.
- 6) Fill first bottle 2/3 full, cap and shake vigorously to aerate. Fill completely (minimizing air space) and record temperature. Cap tightly and set aside.
- 7) Repeat (6) for rest of bottles. Be careful not to mix up lids.
- 8) Repeat (4) through (6) for second turbidity reading, background sample, and remaining bottles.

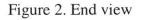
** NOTE: There is no need to be "sterile" during this procedure because all samples are coming from the same source and will therefore have the same initial microbial concentrations. However, it is necessary to take precautions not to contaminate samples with outside sources. **

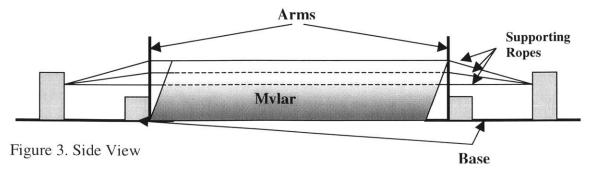
Reflector Assembly

The reflector consists of two parallel "slings" of material (Aluminum coated Mylar or brown paper with Aluminum Foil) hung on rope. Both reflectors are constructed exactly the same way, but using different materials. Each "sling" holds three bottles end-to-end (total = 6 bottles). The reflector should be oriented parallel to the path of the sun (approx East – West) so as to minimize shadows. Samples not utilizing the reflector should be placed at a sufficient distance and orientation away from the reflector so as not to be affected by potential reflection.









Assembly Instructions:

- 1) Choose a location free of shade (that will remain free of shade) and shielded from wind. If a wind shielded location is not available, you may have to rig up a wind block, as the wind affects bottle temperature and may also adversely affect the reflector.
- 2) Bolt arms to the inner side of the longer base piece with bolt heads facing outwards. This will allow the Mylar to rest on the ground without interference from the base or bolts. Three arms attach to each base.
- 3) Tape (using duct tape) one piece of rope to underside of Mylar down middle seam
- 4) Place the two bases approximately 3 feet apart. Flip over Mylar and position between the two bases.
- 5) Thread rope through middle arm on each side and through the back rope holes of the base and tie off. Be sure to pull the rope tight, but do not wrinkle Mylar.
- 6) Thread remaining two rope pieces through the side arms and attach to tie off on both sides as done above.
- 7) Tape outsides of Mylar to side ropes using duct tape.
- 8) Readjust ropes and Mylar to get rid of any slack or wrinkles.
- 9) If necessary, weight down the base with rocks to keep from flipping over.

Temperature Monitoring

Equipment: Checktemp electronic thermometer Sterile or boiled water (for rinsing thermometers) Squirt bottle Bottle Temperature data sheet

** In order to keep thermometers sterile and avoid contaminating samples, they should be left in the sun during the day and rinsed well with boiled water between samples**

Procedure:

- 1) Take temperature in every bottle every hour (or as often as possible) as long as you are awake, starting at t=0 being when the bottles are first set in the sun.
- 2) Take ambient air temperature and note weather condition (ie. approximate wind speed) on temperature data sheet.
- 3) Take reading in first bottle and record on data sheet.

** Only open bottle when ready to take measurement and close immediately after. BE CAREFUL not to shade other bottles while taking temperature readings **

- 4) Rinse thermometer with sterile or boiled water. DO NOT wipe dry.
- 5) Repeat (2) and (3) for remaining bottles.
- 6) Make any necessary notes on data sheet.

SODIS Bottle Temperature - Haiti, January 2002

Date: Exposure Regime:

						Temp	erature	(oC)						
	Time												T	
Bottle	source	0	1	2	3	4	5	6	7	8	9	10	11	12
Time														
Radiatio	n data													
C-a1														
C-a2														
C-b1														
C-b2														
C-c1														
C-c2														
UV1-a1														
UV1-a2														<u></u>
UV1-b1														
UV1-b2														
UV1-c1														
UV1-c2														
UV2-a1														
UV2-b1														
UV2-c1														
Ambien	t													
Weather														

Notes:

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Microbial Analysis

** Remember to complete a blank with sterile water at the beginning and end of each sampling round. **

Equipment:

Filtration apparatus	Funnels
Petri dishes	Media packets
Filters	Tweezers
Sterile Water	Alcohol
Candle and matches	Incubator
Paper towels	Plastic trash bag
Labeling marker	Microbial Analysis data sheet

Procedure:

- 1) Pull back hair, don glasses, use gloves or wipe hands with alcohol
- 2) Prepare work surface: open plastic bag and wipe down with an alcohol soaked paper towel
- 3) Wash hands with alcohol
- 4) Set up filtration apparatus, set out equipment, wipe down outside of samples with alcohol, set out and light candle
- 5) ****** BE CAREFUL not to get alcohol on the LIDS of the bottles but only wipe down the sides to avoid cross contamination ******
- 6) Prepare media: snap open packet, pour entire packet into petri dish and cover immediately
- 7) ****** PREPARE ALL petri dishes at once in order to minimize time filter is exposed to open air later. ******
- 8) Sterilize tweezers in candle, pick up and sterilize carbon filter in candle using tweezers, replace in filtration apparatus and wet with sterile water
- 9) Wash hands with alcohol, sterilize tweezers.
- 10) Carefully open new filter package, pulling away package and paper, DO NOT touch filter with hands (if so, discard filter)
- 11) Pick up filter with tweezers and carefully center on filtration apparatus, place new funnel on top of filter. If filter rips discard filter.

- 12) Carefully pour sample directly from bottle or whirl pack into the funnel, filling to the 100ml (or other appropriate) mark. DO NOT touch container to filter funnel. Close and set rest of sample aside in case it is needed later
- 13) Pull sample through filter, expelling wastewater into waste bucket or onto ground.
- 14) Sterilize tweezers
- 15) Remove filter funnel and pick up filter by edge with tweezers and place in petri dish (held in hand). Avoid air bubbles. Close petri dish immediately and label with sample, exposure and date.
- 16) Repeat from step 6 until all samples are completed.
- 17) Incubate samples for 24 hours, along with background and blanks.
- 18) When done, discard all used funnels, the garbage bag, paper towels and other trash. Empty bottles, wash with soap and boiled water and store under plastic sheet overnight (can also wash the next morning).

After 24 hours:

Count colonies formed (red = Total and blue = E.Coli) and record on data sheet.

Make note of any necessary details (from filtration or counting – e.g. spilled sample?) on data sheet.

Run #: SODIS Microbial Analysis - Haiti, January 2002

Dates: _____

5 hr expo	sure		1-day ex
Sample	Total	E.Coli.	Sample
BL1			BL1
BG1	ļ		BG1
BG2			BG2
BG3			BG3
BL2			BL2
BL3			BL3
C-a1			C-a1
C-a2			C-a2
C-b1			C-b1
C-b2			C-b2
C-c1			C-c1
C-c2			C-c2
C-d1			C-d1
C-d2			C-d2
UV1-a1			UV-a1
UV1-a2			UV-a2
BL4			BL4
UV1-b1			UV-b1
UV1-b2			UV-b2
UV1-c1			UV-c1
UV1-c2			UV-c2
UV2-a1			UV2-a1
UV2-a2			UV2-a2
UV2-b1			UV2-b1
UV2-b2			UV2-b2
UV2-c1			UV2-c1
UV2-c2			UV2-c2
BL5			BL5

1-day ex	posure	
Sample	Total	E.Coli.
BL1		
BG1		
BG2		
BG3		
BL2		
BL3		
C-a1		
C-a2		
C-b1		
C-b2		
C-c1		
C-c2	ļ	
C-d1	ļ	
C-d2		
UV-a1		
UV-a2		
BL4	ļ	
UV-b1		
UV-b2		
UV-c1		
UV-c2		
UV2-a1		
UV2-a2	ļ	
UV2-b1	ļ	
UV2-b2	_	
UV2-c1		
UV2-c2		
BL5	<u> </u>	

2-day ex	posure	
Sample	Total	E.Coli.
BL1	L	
BG1		
BG2		
BG3		
BL2		
BL3		
C-a1		
C-a2		
C-b1		
C-b2		
C-c1		
C-c2		
C-d1		
C-d2		
UV-a1		
UV-a2		
BL4		
UV-b1		
UV-b2		
UV-c1		
UV-c2		
UV2-a1	<u> </u>	
UV2-a2		
UV2-b1		
UV2-b2		
UV2-c1		
UV2-c2		
BL5		

Notes:

Incubator Directions

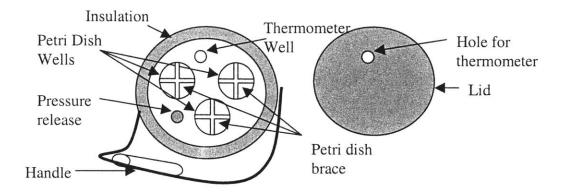


Figure 1. Top view of phase-change incubator

To heat:

- 1) Place incubator in pot, ensuring space between the incubator and the pot with rocks or other objects so that plastic does not melt.
- 2) Fill with water up to brim of incubator
- 3) Boil 15 20 minutes, or until contents of incubator has liquefied
- * NOTE: occasionally lift and "swish" incubator to ensure even distribution of heat *
- 4) When ready, allow incubator to super cool and start crystallization before filling.
 * Note: you can "jump start crystallization by touching the side of the incubator *
- 5) To release pressure from heating open valve and close again.

Alternative: Place incubator in direct sun to heat.

To use:

- 1) Place petri dishes inside brace and lower into wells (5 or 6 into each well). If not brace is available use string.
- 2) Place lid on top. If lid does not sit tightly, cover with a piece of cloth or stuff with extra insulation
- 3) Insert thermometer through lid and into the thermometer well.
- 4) Allow samples to incubate for 24 hours. Check temperature occasionally, when it drops below 35 degrees C, reheat.

Solar Energy Readings

Equipment: Pyranometer Radiation data sheet Bottle Temperature data sheet Pencil Black cloth cloak

Procedure:

- 1) Take normal radiation reading every hour and record on Bottle Temperature data sheet.
- 2) At peak time (approx. noon) each day take the following measurements:
 - on reflector
 - through plastic piece
 - through full bottle (cloaked in black cloth)
 - through full painted black bottle (cloaked in black cloth should be 0)
 - through full foil wrapped bottle (cloaked in black cloth should be 0)
- 3) Cover sides of bottle with black cloth.
- 4) Place full bottle covered in cloth over pyranometer, record reading on Radiation data sheet.

Turbidity & Radiation - Haiti, January 2002

Dates:

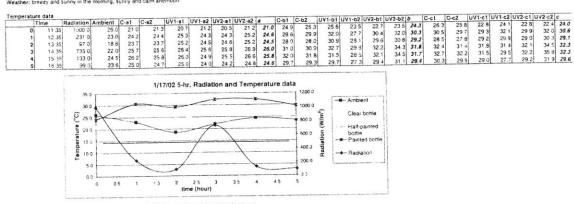
		Turbi	dity (NTU)	R	adiation Transi	nissivity		
Day	Date	1	2	3 pla			bottle	painted	foil
1-1									
1-2									
1-3									
1-4									
2-1									
2-2									
2-3									
2-4									
3-1									
3-2									
3-3									
3-4									
4-1									
4-2									
4-3									
4-4									
5-1									
5-2									
5-3									
5-4									
6-1									
6-2									
6-3									
6-4									

Notes:

APPENDIX II: Data Summary and Analysis

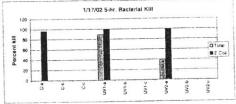
Barasa, Run 1 5-hour: 1/17/02

Weather: breezy and sunny in the moming, sunny and caim afternoor



Evaluation, reached threshold radiation for approximately 1, 1/2 hours, did not exceed threshold temp

Bacterial	Bun 1-1		Run1-2		Average	Le conservation de la conservation	% kill			
Sample	Total	E.Coll	Total	E.Coli	Total	E.Coll	Total	E.Coll		
BL	1	0	0	0	0.5	0				
BG	2500	2500	2500	2500	2500	2500				
C-a	2500	109	2500	96	2500	102.5	0	95 9		
C-b	2500	2500	2500	2500	2500	2500	0	0		
C-c	2500			2500	2500	2500	0	0		
UV1-a	292		256	2	274	2	89.04	99 92		
UV1-b	2500				2500	2500	0	0		
UVIC	2500				2500	2500	0	0		
UV2-a	2500				1514	21	39 44	99 16		
UV2-b	2500				2500	2500	0	0		
UV2-c	2500					2500	0	0		



Barasa, Run 2 S-hour: 1/20/02

Sunny and calm Weather

UV1-1 19 2 28 3 31 6 31 0 28 8 26 0 C-a1 183 261 294 304 296 276
 C-c1
 C-c2
 UV1-c1
 UV1-c2
 UV2-c

 18.8
 19.6
 21.5
 22.1
 21.

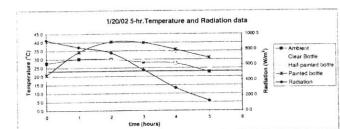
 33.5
 32.2
 27.4
 42.3
 35.

 37.7
 37.3
 41.6
 46.8
 38.

 41.0
 94.9
 91
 42.5
 36.

 39.6
 37.0
 33.0
 36.4
 32.
 UV1-2 UV2-8 (2 18 9 19 5 3 27 3 27 0 5 29 8 28 9 0 28 4 27 9 3 26 5 25 8 1 23 5 22 8
 C-61
 C-b2
 UV1-b1
 UV1-b2
 UV2-b
 b

 18.6
 19.6
 21.6
 21.4
 21.4
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 21.4
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 21.5
 31.3
 31.3
 35.3
 35.6
 30.5
 data 27 5 30 1 30 0 28 3 27 7 20.7 34.2 40.3 39.7 35.7 30.9 20.6 33.3 37.4 37.3 34.0 Radiation C-a2 2 18 2 25 8 28 9 30.0 28 8 21.7 35.7 38.1 36.7 32.7 914 0 824 0 751 0 526 0 294 0 1.00 2.00 3.00 4.00 1 2 3 125 0 22 235 22.8



Evaluation. Threshold temperature not met, but threshold radiation was exceeded for 3 hours

	Bun2-1		Run2-2	10000	Average		% Kill								Beele	rial Kill		
Sample	Total	E.Coll	Total	E.Coll	Total	E Coli	Total	E Coli	- 16 C				1/20	102 3-m	. Dacie	1140 1510		
L	0	0	0	0	0	0			12	0 00								
G	2500	385	2500	396	2500				10	0.00	-				-			
-a	1580	0	2500	0	2040				3	00 00				15			_	
-b	2500	2500	2500	2500	2500	2500	0.00	-540 20	1 2 1	0.00	-			2			18	
-c	2500	2500	2500	2500					5	50.00				- 68				
IV1-a	320	0	330	0	325	0	87.00		2	00 04	-			- 11 -			- 13	- 18
JV1-b	2500	0	2500	10			0.00		a.					122			間	
JV1-c	2500	480	2500	2500	2500	1490		-281.56		20 00	10			1	-		1	12
V2-a	1010	0	145	0	578				1	0 00	182			100			-	
JV2-b	2500	0	165	0	1333	0					3	3	X		0-1	2	29	-
UV2-c	2500	240	2360	0	2430	120	2.80	69.27	1		0	0		3	3	3	3	

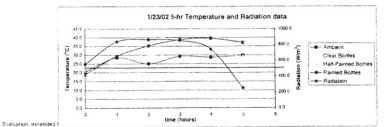
D Total

UV2-C

Barasa, Run 3 5-hour 1/23/2002

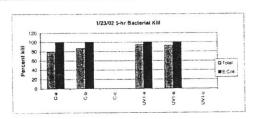
Weather: Mostly sunny, breezy in the atternoon

	Time	F	Radiation	Ambient	C-a1	C-a2	UV1-1	UV1-2	UV2-a		C-b1	C-b2	UV1-b1	UV1-b2	UV2-b	b	C-c1	C-c2	UV1-c1	UV1-c2	UV2-c	C
0	100	0	550 0	20.4	18 1	18 3	19.3	19.2	20 0	19.0	188	20 5	22.1	21.4	212	20.8	18 8	19.0	20.0	20.2	21 0	1
1	110	0	837 0	28.5	235	23.5	27 3	27 5	28 2	26.0	28.3	28 5	35 8	34 5	35 8	32.6	29 3	29.5	32 2	32.4	32.6	2
2	120	10	862 0	25 (26 5	26 5	31.0	31.8	32.4	29.6	33 6	33 0	40.7	408	43.7	38.4	35 8	34.6	35.8	40.7	41.2	3
3	10	a	850 0	29 3	29 2	28 8	32 0	33 B	34.7	31.	37 3	36 2	428	425	45.4	41.0	39 2	38.2	39 4	45 3	45.5]]
4	20	0	740 0	28 1	30.1	29 3	31 3	32 9	33.6	31.	38 4	36.3	41.4	40 3	46.8	40.6	39 7	39 3	37 3	44 2	44 3	3
5	3.0	ol	250 0	29.8	28.1	27.3	29.0	30.0	30 5	29.4	34.5	33.6	36.2	35 5	40.3	36.0	34.7	39.7	33.9	36.1	38 1	3





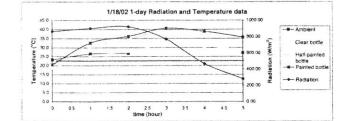
	Run3-1		Run3-2		Average		% Kill	
Sample	Total	E.Coli	Total	E.Coli	Total	E.Coli	Total	E.Coll
BL.	0	0	0	0	0	0		
BG	2500	340	2500	900	2500	620		
C-a	1040	0	60	0	550	0	78	100
C-b	400	0	270	0	335	0	86 6	100
C-c	2500		2500	460	2500	1480	0	-1387
UV1-a	30	0	240	0	135	0	94 6	100
UV1-b	260	0	110	0	185	0	92 6	100
UV1-c	2500		2500	2500	2500	1360	0	.119 1



Barasa, Run 1 1-day: 1/18/02

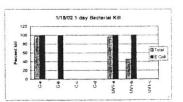
Weather: breezy and partly cloudy

	Time	Radiation	Ambient	C-a1	C-a2	UV1-#1	UV1-a2 a		C-b1	C-62	UV1-b	UV1-b2	b	C-c1	C-c2	UV1-c1	UV1-d	C	C-d1	C-dZ	C-d
0	11:00	865.00	23 2	18 3	18 2	19 3	19.5	18.8	19.1	19.5	21.8	20.2	20.2	19.8	18.6	21.7	22.0	20.5	17.9	18.0	18
1	12 00	900.00	28.5	24.6	237	26 4	25.6	25.1	29 B	27 5	35 5	28 8	30.4	29.5	27 9	38.0	35 0	32.5	22.0	215	21
2	1 00	920.00	26 8	27 9	26 7	28 4	29 1	28.0	34 7	318	38 2	34 0	34.7	36 0	32 3	38 4	38.0	36.2	25 1	24 3	24
3	2 00	770 00		31.5	29 8	30 8	33 0	31.3	39 8	37.1	42.7	38.7	39.6	41 2	37 9	419	41.0	40.5	27 8	26.5	27
4	3.00	457 00		31.2	29 7	29.7	31.5	30.5	39.6	36.9	40 8	36.7	38.5	40.5	36 8	40 6	37.8	38.9	28.1	26 3	27
5	4 00	280 00	27 0	31 5	29 6	27.0	28 5	29.2	39 0	35 3	35 4	31 4	35.3	40 2	35 3	35.5	31 6	35.7	28 3	26 2	27.
6	5 00	84 00		28.0	27 2	24.0	24 8	26.0	33 9	30.6	29.4	25 8	30.2	34.9	31 2	29 5	25.6	30.5	27 0	24.8	25



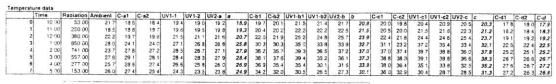
Evaluation: reached threshold radiation for 4 hours, did not exceed threshold temp

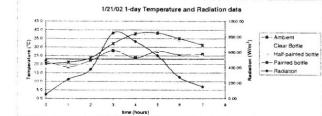
	Run1-1		Run1-2		Average		% kill	
Sample	Total	E.Coli	Total	E.Coli	Total	E.Coll	Total	E.Coll
BL	0	0	1	0	0.5	0		
BG	2500	2500	2500	2500	2500	2500		
C-3	75	c	47	0	61	0	97 56	100
C-b	2500	0	2500	20	2500	10	0	99.6
C.c	2500	2500	2500	2500	2500	2500	0	0
C-d	2500	2500	2500	2500	2500	2500	0	0
UV1-a	150	0	47	0	98 5	0	96.06	100
UV1-b	240	0	2500	1	1370	0.5	45 2	99.98
UV1-c	2500	2500	2500	2500	2500	2500	0	0



Barasa, Run 2 1-day: 1/21/02

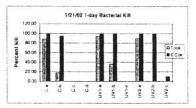
Weather: morning overcast and windy, alternoon sunny and calm





Evaluation. Threshold temperature not met, but threshold radiation was exceeded for 3 hours

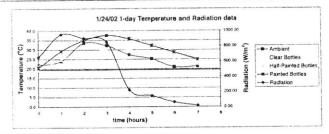
	Run2-1		Run2-2	12.00	Average		% Kill	
Sample	Total	E.Coll	Total	E.Coli	Total	E.Coli	Total	E.Coli
BL	0	0	0	1	0	1		
BG	2500	1680	2500	590	2500	1185		
C-a			290	0	290	0	88.40	100 00
C-b	1540	70	2500	60	2070	65	17.20	94 51
Cc	2500	1580	2500	1430	2500	1505	0.00	-27.00
C-d	2500	1400	2500	1280	2500	1340	0.00	-1308
UV1-a	200	0	110	0	155	0	93 80	100 00
UV1-b	2500	0	710	0	1605	0	35.80	100 00
UV1-c	2500	1430	2500	2500	2500	1965	0.00	-65 82
UV2-a	250	0			250	0	90.00	100.00
UV2-b	2500	0			2500	0	0 00	100.00
UV2-c	2500	1070			2500	1070	0.00	970



Barasa, Run 3 1-day: 1/24/2002

Weather: Morning sunny and breezy, attemoon overcast and windy

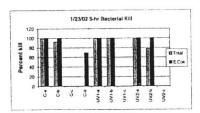
	Time	Radiation	Ambient	C-#1	C-82	UV1-1	UV1-2	UY2-a	a	C-b1	C-b2	UV1-b1	UV1-b2	UV2-b	b	C-c1	C-c2	UV1-c1	UV1-c2	UV2.c C		C-d1 (C-d2	C.d
	10.00	650.00	21.0		17	4 20.6			19.3	196	18.3	23 1	22.7	23.1	21.4	18 0	184	21.6	21.5	22.4	20.4	17 2	171	17.
0			210	1/1	22	1 1000	10200	26.6	10000			34.5	32.4		30.3	26.9	25 8	29 9	31 0	32 2	29.2	20 5	20.8	20
1	11 00	950 00	24 0			1.000				31.8		39.9	39.0		35.8	32.7		34.3	37.2	37.9	34.9	23.7	247	24
2	12 00	901 00	33.5			8 30.6	30 3					1 1 2 2 1 2	000	387	37.7	36 5		36 7	39.0	38.9	37.5	26 3	27.0	26
3	1 00	850.00	32 2	28	1 28	1 31.8	307	32.1		35.6		410	31.0		31.1			30 7		201	35.7	27.5	28 0	27
4	2.00	221.00	27 4	28	7 28	6 30 9	29 8	32.0	30.0	36 5	36.2	38 3	34 8		36.7	37.4		33.3	35 0	30 1				1
5	3 00	145 00	25 2	27	4 27	6 28 5	27 4	29 2	28.0	33.9	336	33 6	30.9	33.5	33.1	34 7	33 6	30.0	30.3	31 9	32.1	27 2	27.6	
	4 00			25	25	4 25 7	247	26 3	25.5	30 0	29 8	29 5	27.5	29 2	29.2	30 8	29.7	27 4	26 8	28 3	28.5	25.8	25 9	
	5.00			23	1	8 22.6		23 1	22.8			25 2	23.9	25.5	25.2	26.5	25.9	23.7	23 3	24 8	24.9	24.1	24.4	24.



Evaluation, exceeded threshold radiation levels for 3 1/2 hours, did not exceed threshold temperature

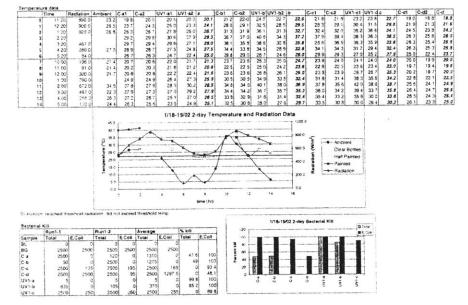
act	 la!	KIII	

	Run3-1		Run3-2		Average		% KIII	
Sample	Total	E.Coll	Total	E.Coll	Total	E.Coll	Total	E.Coli
BL	1	0	0	0	0.5	0	1	
BG	2500	870	2500	130	2500	500		
C-a	30	0	10	0	20	0	992	100
C-b	250	0	160	0	205	0	918	100
C-c	2500	110	2500	2500	2500	1305	0	.161
C-d	2500	170	2500	140	2500	155	0	69
UV1-a	40		0	0	20	0	99 2	100
UV1-b	0	0	20	0	10	0	99 6	100
UV1-c	2500	2500	2500	160	2500	1330	0	-166
UV2-a	50			1	50	0	98	100
UV2-b	560				560	0	77.6	100
UV2-c	2500				2500	2500	0	-400



Barasa, Run 1 2-day: 1/18-19/02

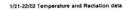
Weather: breezy and partly cloudy

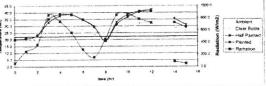


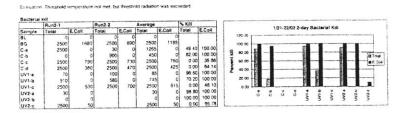
Barasa, Run 2 2-day: 1/21-22/02

Weather: morning overcast and windy, afternoon sunny and calif

1	Time	Radiation	Ambient	C-#1	C-a2	UV1-1	UV1-2	UV2-a		C-b1	C-b2	UV1-b1	UV1-b2	UV2-b	b					UV2-c c	
- n	10 00	53 0	217	150	18	187	18 9	18.8	18.5	18 9	18.6	20.4	19 5	20.8	19.7	20.3	197	19.5	20.6	20.3	20.
	11.00	250 0	18 5		18		19.3	19.5	19.0	197	196	21 2	21 2	21.7	20.7	20.0	199	20 9	212	21.7	20.1
2	12.00	360 0	22.2		19	4 20.6	20.8	21.5	20.4	21.5	21.3	23 4	23 5	25.1	23.0	21 6	215	23.3	23.7	25.8	23.
1	1 00		28 0		23	5 25 7	27.9	27.5	25.7	29 8	29 8	32.0	35 4	36.8	32.5	30 7	312	35 5	39 5	38.9	35
1	2.00	741 0			25		32.6	30.0	28.6	34 9	34.8	34 7	421	41.7	37 5	367	36 0	34.5	44 4	41.9	38.1
5	3 00				28		32.6	29.5	29.3	37 2	36 4	33 8	42.2	42.0	38 3	37 1	36 9	340			38.
	4 00		25.7	1	26	5 25 1	29 2	27.6	27.1	34 5	34 3	29 8	36 5	37.9	34.6	35 3	34 2	29.9		37.7	34
7	5.00	153.0	26 0		24	2 22 5	25 0	24.9	24.2	30.3	29 2	25 6	29 0	32.0	29.2	30 8	30 1	25 5	28 7	32.2	29.
	10 00	450 0	24 7		17	9 18.3	18.4	18.4	18.3	18 9	15.4	197	19 5	19.9	19.3	187	18 5			19.5	19.0
9	11 00	850 0	27.4	24 3	24	26 8	27 1	26.1	25.0	29.5	29 3	35 0	31 2	38.3	32.7	31.0				32.7	31.
10	12 00		31 0	27 8	27	4 30 2	30 5	30.6	29.7	34 8	34 9	40 9	35 9	45.5	38 4	36 9	36 7	33 1	38 3		36.
11	1.00	782.0			29	6 31 9	331	33.0	31.9	38.7	38.0	44 2	39 1	44.7	40.9	41 9					40.
12	2 00		25 7		30	5 32.2	33.7	33.4	32.5	39 3	390	43.8	39.5	48.1	42.0	42.9	42 1	36.5	41.4	42.2	41.1
13	3 00			1000						1									2	1	
14	4 00	84 0	22 5	29 2	29	0 28 5	29 2	29.7	29.2	35 5	347	35.9	32 3	39.0	35.6	37 8	37 1			22.5	32.1
15	5.00	50 0	22 5		26	5 26.7	26 4	26 9	26.6	30.5	30 3	31 0	28 5	33.3	30.7	33 2	32 3	29 3	28.5	22.5	29.

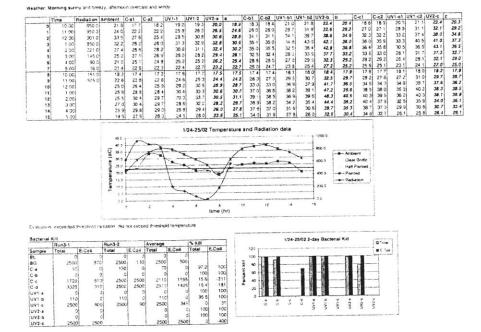






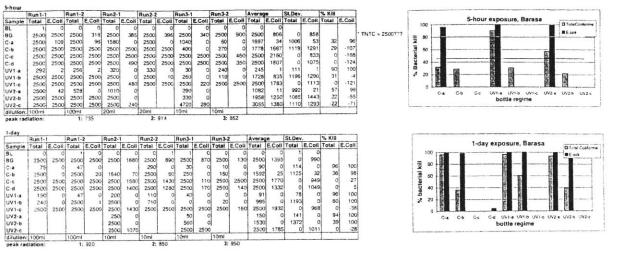
91

Barasa, Run 3 2-day: 1/24-25/2002

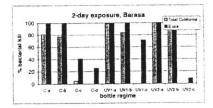


Barasa - Microbial data summary

let TNTC = 2500

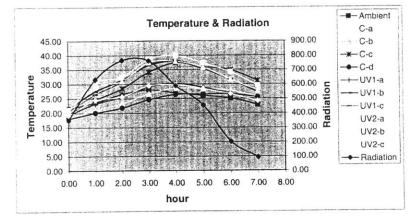


	Bun 1-		Bun1-2		Runz-1		Run2-	2	Run3-1		Run3-2		Averag		St.Dev.	100	% Kill	_
Sample	Total	E.Coll	Total	E.Coll	Total	E.Coll	Total	E.Coll	Total	E.Coll	Total	E.Coli	Total	E.Coli	Total	E.Coll	Total	E.Coli
BL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
BG	2500	2500	2500	2500	2500	1680	2500	690	2500	870	2500	130	2500	1395	0	990		
C-a	5	C	120	0	2500	0	30	0	10	0	130	0	466	0	998	0		100
C-b	50	0	2500	0	0	0	900	0	0	0	0	0	575	0	1008	0		
C-c	2500	135	2500	195	2500	790	2500	730	1720	610	2500	2500	2370	827	318	864	5	
C-d	2500	2500	2500	95	2500	380	2500	470	3320	310	2500	2500	2637	1043	335	1136	-5	25
UV1-a	5	0	5	0	70	0	100	0	0	0	0	0	30	0	44	0		
UV1-b	635	G	105	0	910	0	580	0	110	0	110	0	408	0	347	0	84	100
UV1-c	2500				2500	530	2500	700	2500	500	2500	90	2500	405	0	239	0	71
UV2-a					30	0			0	0	6	6 8	15	0	21	0	99	100
UV2-b					0	0			0	0			0	0	0	0	100	100
UV2-c	1				2500	50		1	2500	2500	i		2500	1275	0	1732	0	1 5
dilution	20ml		20ml		10mi		10ml		:0m1		10ml						1	
peak rad	fiation:		1:	790			2	867			3.	575						

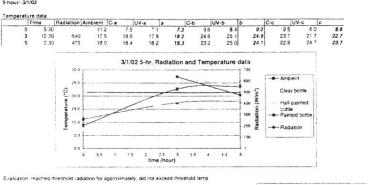


Barasa - temperature data summary

Time	Radiation	Ambient (C-a	C-b	C-c	C-d	UV1-a	UV1-b	UV1-c	UV2-a	UV2-b
0.00	348.33	21.38	18.3	19.41	19.5	17.96	19.3	21.36	20.5	19.2	21.1
1.00			21.0	24.14	24.5	20.06	23.2	27.53	26.4	24.5	30.8
2.00			23.3	27.69	28.5	21.85	25.6	31.38	30.8	25.7	32.5
3.00		0.000	26.7	33.22	34.1	24.63	29.1	36.52	37.0	29.4	38.7
4.00			28.5	35.99	37.4	26.35	30.2	37.90	38.2	29.8	40.0
5.00			28.4	35.58	36.0	26.52	28.8	35.34	35.5	28.4	37.3
6.00			27.8	34.02	34.9	26.58	26.7	31.60	31.6	26.6	34.2
7.00			25.6		31.2	25.47	24.2	27.31	27.1	24.2	29.5

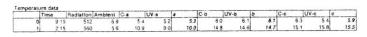


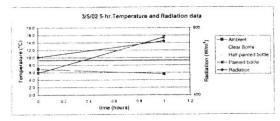
Boston, Run 1 5-hour: 3/1/02



	Run1-1		Run1-2	18 97 19 90 61 11 19	Average		% kill				120 1							
Sample	Total	E.Coll	Total	E.Coli	Total	E.Coll	Total	E.C	oli	- E	100	10000						
BL	0	0	0	0	0	0				1	100	13	1557		10	1		
BG	600	115	1000	75	800	95				3	-	100	12				-	-
C-a	5	5	35	0	20	2.5	1 1	98	97		80	- 23	一個					
C-b	40	0	125	0	82.5	0		90	100	1	40	- 8			- Q			
C-c	1000	55	1600	50	1300	52.5	-	53	45		20	12 ·					1	_
UV-a	35	0	0	0	17.5	0	1	38	100			10					1	
UV-b	35	0	50	0	42 5	0		35	100		0	1	9			7	ą	v
UV-c	1200	20	1370	35	1285	27 5		61	71			0	Û	8	٥	3	2	3

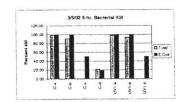
Boston, Run 2 5-hour: 3/5/02





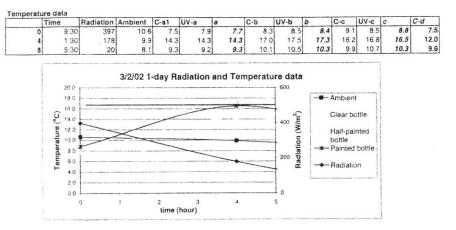
Evaluation: Threshold radiation was exceeded

	Run2-1		Bunz-2		Average		™6 Ki∎	
Sample	Total	E.Coli	Total	E.Coll	Total	E.Coll	Total	E.Colt
BL	0	0	0	0	0	0		
BG	1400	55	1400	85	1400	70	1	
C-3	20	c c	35	0	28	0	98 04	100.00
C-b	160	0	110	0	135	0	90 36	100.00
C-c	1400	30	1400	40	1400	35	0.00	50 00
C-d	1000	70	1200	45	1100	58	21.43	17.86
UV1-a	40		20	0	30	0	97 86	100.00
UV1-b	75		110		93	0	93 39	100 0
UV1-c	1400	45	1400	25	1400	35	0.00	50.0



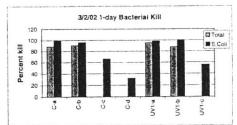


Weather: hazy, breezy



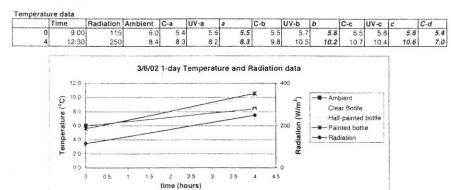
Evaluation: did not exceed threshold temp or radiation

	Run1-1		Run1-2		Average		% kill	and the second second
Sample	Total	E.Coli	Total	E.Coll	Total	E.Coli	Total	E.Coli
BL	0	0	0	0	0	0		
BG	750	75	750	160	750	117.5		
C-a	60	0	115	0	87.5	0	88	100
C-b	60	0	80	10	70	5	91	96
C-c	1200	55	1350	25	1275	40	-70	66
C-d	1200	80	1220	80	1210	80	-61	32
UV1-a	35	0	40	5	37.5	2.5	95	98
UV1-b	55	0	130	0	92.5	0	88	100
UV1-c	1200		1400	70	1300	52.5	-73	55



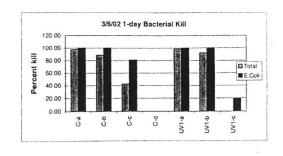
Boston, Run 2 1-day: 3/6/02

Weather: hazy, breezy



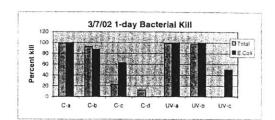
Evaluation: did not exceed threshold temp or radiation

	Run2-1		Run2-2		Average		% Kill	
Sample	Total	E.Coli	Total	E.Coli	Total	E.Coli	Total	E.Coli
BL	0	0	0	5	0	3		
BG	1400	60	1200	70	1300	65		
C-a	20	0	45	0	33	0	97.50	100.00
C-b	170	0	130	0	150	0	88.46	100.00
C-c	650	20	850	5	750	13	42.31	80.7
C-d	1600	110	1600	100	1600	105	-23.08	-61.54
UV1-a	15	0	25	0	20	0	98.46	100.00
UV1-b	125	0	85	0	105	0	91 92	100.00
UV1-c	1000	60	1600	45	1300	53	0.00	19.2



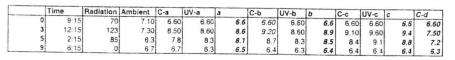
Boston, extra 1-day 1-day: 3/7/02

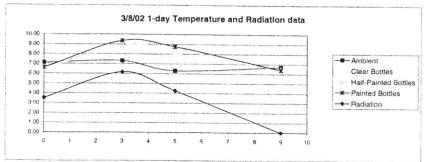
	Run3-1		Run3-2		Average		% Kill	
Sample	Total	E.Coli	Total	E.Coli	Total	E.Coli	Total	E.Coli
BL	0	0	0	0	0	0		
BG	1.300	10	1100	30	1200	20		
C-a	0	0	30	0	15	0	99	100
C-b	100	0	75	5	88	3	93	88
C-c	800	10	1050	5	925	8	23	63
C-d	1100	30	1000	15	1050	23	13	-13
UV-a	20	0	15	0	18	0	99	100
UV-b	40	0	30	0	35	0	97	100
UV-c	1250	15	1200	5	1225	10	-2	50



Boston, extra 1-day 1-day: 3/8/2002

Weather: overcast and windy



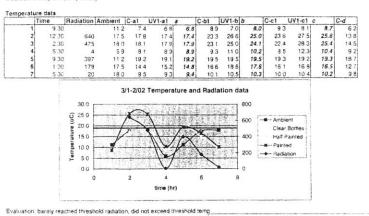


Evaluation, did not exceed threshold temp or radiation

	Run4-1		Run4-2		Average		% Kill		
Sample	Total	E.Coli	Total	E.Coli	Total	E.Coli	Total	E.Coll	3/8/02 5-hr Bacterial Kill
BL	0	0	0	0	0	0			
BG	2000	70	1400	45	1700	57.5			120
C-a	800	5	1000	0	900		1	95.652	100
C-b	1000	0	1000	10	1000	5	41.176		80 01
C-c	1000	60	1400	45	1200	52.5	29.412	8.6957	60
C-d	1000	55	1600	65	1300	60	23.529	-4.348	
UV1-a	1000	0	800	0	900	0	47.059		20
UV1-b	1000	5	1000	10	1000	7.5	41.176	86.957	
UV1-c	800	35	1600	55	1200	45	29.412		5 5 5 5 5 5

Boston, Run 1 2-day: 1/1-2/02

Weather: breezy and partly cloudy

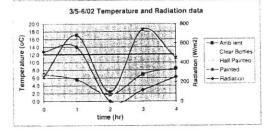


Bacterial							1 G									OT.
	Run1-1		Run1-2				13	0								
Sample	Total	E.Coll	Total	E.Coli	E.Coll	E.Coll	16	10				-	- 1	-		
BL	U	0	0	0	0		3 .	10						à	-03	
BG	600	115	1000	75	95		2	10				1.			ě.	
C-a	25	0	45	0	0	100	5	1	-	FL			-	2	ii.	
C-b	60	0	40	0	0	100		10	當	一度					12	
C-c	600	15	1000	60	37 5	60 526		0	1					18 -	-65	
C-d	1400	100	1400	110	105	-10.53		0	碧	E.				н.,	8	_
UV1-a	15	0	35	0	0	100			3	-	3		ŝ	2	2	9
UV1-b	65	0	45	0	0	100								3	3	3
UV1-c	600	70	800	60	65	31 579						_				

Boston, Run 2 2-day: 3/5-6/02

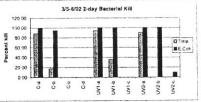
Weather: morning overcast and windy, atternoon sunny and calm

	Time	Radiation	Ambient	C-a1	UV1-1	a	C-b2	UV1-bb		C-c1	UV1-c1	C	C-d
0	9 15	512	69	5.2	58	5.5	6.8	6.8	6.8	6.2	6.2	6.2	53
1	2 15	560	56	10.7	11.3	11.0	145	18 3	16.4	13 6	20.6	17.1	77
2	6 15	0	1.7	09	1.1	1.0	14	25	2.0	1.2	36	2.4	2 5
3	9 00	115	6.9	18.6	18.3	18.5	187	18.2	18.5	18.8	18.2	18.5	188
4	12:00	250	34	92	10.0	9.6	109	126	11.8	9.8	12.5	11.2	9 :



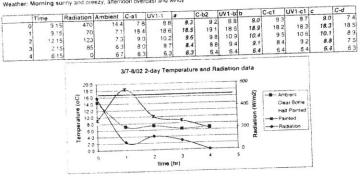
Evaluation: Threshold temperature not met, but threshold radiation was exceeded

	Run2-1		Run2-2			
Sample	Total	E.Coli	Total	E.Coli	E.Coli	E.Coli
BL	0	0	0	0	0	
BG	1400	55	1400	85	70	
C-a	25	0	15	0	0	100.00
C-b	25	0	30	0	0	100.00
C-c	1400	65	1200	35	50	28.57
C-d	2500	190	1200	35	113	-60.71
UV1-a	65	0	5	0	0	100.00
UV1-b	455	0	40	0	0	100.00
UV1-c	2500	265	1000	30	148	-110.71



Boston, Run 3 2-day: 1/24-25/2002

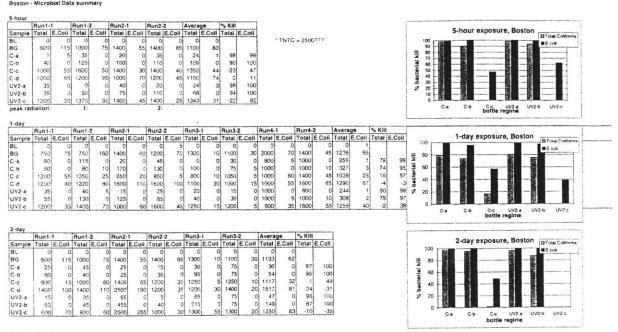
Weather: Morning sunny and preezy, atternoon overcast and windy



Evaluation: exceeded threshold radiation, did not exceed threshold temperature

Bacterial	Run3-1		Run3-2				13	10			-						
Sample		E.Coli	Total	E.Coli	E.Coli	E.Coli											C.C.
BL BG C-a C-b C-c	0 1300 30 95 1250	0	0 1100 75 75 1250	0	0	100 100 62 5	TR II	60 60 60 40	-		1				Transaction of the		
C-d UV1-a UV1-b UV1-c	1200 85 215 1300	30 0 0	75 75			-25 100 100 -87.5		0 S	C.b.	0,6	C.d	e-170	4-1AD	UVI-C	UV2-6	UV2-6	

Boston - Microbial Data summary

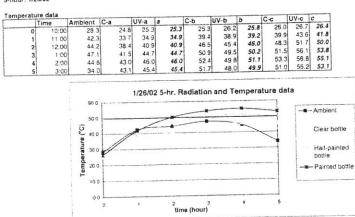


" all 20 ml ditution "

Boston - temperature data summary

Time	Radiation	Ambient	C-a	C-b	C-c	C-d	U	V1-a	UV1-b	UV1-c
0.00		9.00		10.62	10	.7	9.70	10.1	10.41	10.3
3.00				13.55	13	1.3	9.34	11.1	14.66	14.9
5.00				12.78	12	.4	9.32	10.5		
8.00		10.93		11.08	10	0.8	9.32	9.8	11.84	12.1
			Te	mperature	e & Rad	liation			C-a C-b	
	16.0	0	1. 10 1 10 A.S.	L'AGESTRES	N		·	400	€C-c	
	14.0	0	-			日本語を見		250	-C-d	
	12.0	0						300 -	+→ UV-a	
	P 10.0	0					AL BEALL	250		
	0.01 0.8 Lemberature 0.0	0	1 1 1 1 1 1 1 1	Sector and		\mathcal{X} .	41 4 1	200 -	 Radiation 	
	u 6.0	0		CASE AND				150		
	4.0	ю		1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1		187 5 80 9 15 1 1 1 1	1	100		
	2.0	0		1. 8. 9 5 4 4 1 7 40 8 1 5		<u>1919</u>	<u> </u>	50		
	0.0	0.00 1.0	0 2.00	3.00 4.00 Time (5.00 hr)	6.00	7.00	9 0 8.00		

Dumay 5-hour: 1/26/02



Evaluation, painted bottle exceeded threshold temperature for three hours, 1/2 painted for 2 hours

Bacterial	Run1-1		Run1-2		Average		% Kill			S						
Sample		E.Coli		E.Coll	Total	E.Coli	Total	E.Coli	12							_
BL	0	0	0	1	0	0.5			10	-10	-				PET A	
BG	2500	2500	2500	2500	2500	2500			3	0	1 -1		-	-	- 28	
C-a	2500		2500	156		146			1 5 6	0				-	-22	
C-b	272		256	0	264	0			1 1				1			-
C-c	556		432	176	494	137			a					1		1
UV-a	520		2500	2	1510	1	39.6		2	0				1	1.1	
JV-b	102		400	2	251	1	89.96			0	1	0	0	12	P	Ŷ
UV-c	624	2	2500	1	1562	1.5	37.52	2 99.94			3	ö	Ó	3	3	3

rouped Boston and Barses Data

Coll		186	C	UV1-a	UV2-	C-b	UV1-b	UV2-b	Cc	UV1-C	UV2-c
-	Bun 2-1	365	0	0	0	2400	0	0	2400	480	240
	Hun 2-2	396	0	0		2400	10		2400	2400	
	Bun 3-1	340	0	0	0	0	0	0	2400	2400	290
	Bun 3-2	900	0	0		0	0	(460	2400	_
oston	Bun 1-1	115	5		G	0		0	55		20
	Bun 1-2	75	0		0	0		0	50	6	35
	Run 2-1	55	0		0	0		0	- 30		45
					0			0	40		25
	Hun 2-2	85	0		0	0		0	40		
'otal Co		1 85	0	UV1-0			UV1-6			UV1-0	UV2-6
			C-4				UV1-6 2400	UV2-6	C-e		
	ittorma	BG	C-a 1580	320	UV2-8	C-b 2400 2400	2400	UV2-6 2400	C-e 2400 2400	BV1-0 2400 2400	2400
	Run 2-1	8G 2400	C-a 1580	320 330	UV2-8	C-b 2400	2400 2400 260	UV2-6	C-e 2400 2400 2400	2400 2400 2400	UV2-6 2400
	Run 2-1 Run 2-2	8G 2400 2400	C-a 1580 2400	320 330	1010	C-b 2400 2400	2400	UV2-6 2400 330	C-e 2400 2400 2400 2400	8400 2400 2400 2400 2400	UV2-6 2400 4720
lerana	Run 2-1 Run 2-2 Run 3-1	8G 2400 2400 2400	C-e 1580 2400 1040 60	320 330 30	1010	C-b 2400 2400 400	2400 2400 260	UV2-6 2400 330	C-e 2400 2400 2400 2400 2400	8400 2400 2400 2400 2400	UV2-6 2400 4720
lerana	Run 2-1 Run 2-2 Run 3-1 Run 3-2	8G 2400 2400 2400 2400	C-4 1580 2400 1040 60 5	320 330 30	UV2-a 1010 290	C-b 2400 2400 400 270	2400 2400 260	UV2-6 2400 330 35 50	C-e 2400 2400 2400 2400 1000 1600	8400 2400 2400 2400	UV2-6 2400 4720 1200 1370
'otal Co Ierate Ioston	Run 2-1 Run 2-2 Run 3-1 Run 3-2 Run 3-2 Run 1-1	8G 2400 2400 2400 2400 2400 800	C-a 1580 2400 1040 60 5 5	320 330 30 240	UV2-a 1010 290 35	C-b 2400 2400 400 270 40	2400 2400 260	UV2-6 2400 330	C-e 2400 2400 2400 2400 2400	8400 2400 2400 2400	UV2-6 2400 4720

5-hour Mann-Whitney Lest (E.coli)

SG v. C-a						
Analysis Input Column 1 Input Column 2	2 Sampie Rank BG	neters Ho: Median Ditt = 0 Ha: Nut equal to 0 Contidence	0 0.9			
		Desor	ptive Statiat	lica		
	N	Minimum			3rd Guartile	
BG	8	55	83	228	388	900
C-#	8	0	0	c	u	2
		Mann-Whitney	Rank Analys	de		
Median Drtt.	Rank Sum1	Rank Sum2	p-value	lower 90%		. 1
225.00	100 0	36.0	0.000	75.00	391.00	
A CONTRACTOR OF A CONTRACTOR OFTA CONTRACTOR O						
BG V. UV1-a	Paul	meiera				
	Para	Ho: Median Ditl = 0	C			í
Anelysis Input Column 1	2 Sample Henk	Ha: Not equal to 0	0			1
		Contidence	0.9			1
Input Column 2	0.01-0	Comberce	0.0			- 1
		Deecr	ptive Statist	lice		
	N	Minimum .			3rd Quartile	
BG	4	340	374		522	
UV1-a	4	0	٥	٥	. 0	٥
		Mann-Whitney	Rank Analys	eia .		
Median Diff.		Rank Sun2		lower 90%		:)
390 50	26.0	10.0	0.029	340.00	900.008	
BG v. UV2-a	1					
		melers				
Analysis		Ho. Median Diff. = 0	0			1
input Column 1		Ha: Not equal to 0				
input Column 2	UV2-6	Confidence	0.9			
		Descr	iplive Statis	tice		
		Minimum			3rd Quarties	Maxmum
	N		83	228		
86	N	55				
BG UV2-∎			0	0	0	0
	2	0	0			
	2		0	81a	upper 90%	

BG v C-b	1						
		theter s					
Analysis	2 Sample Fiank	Ho: Median Ditl	0	0			
Input Column 1	BG	Ha Not equal to 0	- L	0			
Input Column 2	0.6	Conficience	L	0.9			
		De	aori	ptive Statiet	ice.		
	N	Manamum		lut Quartile		3rd Quartile	
BG			55	83	228		900
Cb	5		0	0	0	600	2,400
			-				
		Henn-White Bank Sum2	iey F	tenk Analys	IS INCOME		
Meckan Dtfl.				0.4800	1 500.00	385.00	
85.00	84.0		2.0	0105		363.00	
BG v. UV1-b	1		50.873 m				
		meters			1		
Analysis		Ho. Mediar. Diff	0	0			
Input Column 1		I Ia Nigi equal to (0.9			
Input Country 2	UV1-0	Contruence	- 1	0.8			
	L]					
		D		plive Statial	los		
	N	Maximum		1 M Quartile	Median	3ro Guartile	Maxmum
BG			340				
UV1-b			۵	0	0	3	10
		Mana White	-	Rank Analys	-		
Mudain Diff.	Bank Sum1	Hank Sum2		D-Value	lower 90%	upper 90%	
			0.0	0.029	340.00	890 00	
	20.5						
385.54							
	And the second second						
385 50 BG v. UV2-6		melers					
BG v. UV2-6 Analysia	2 Semple Fank	Ho: Mataun Det		D			
BG v. UV2-6	2 Semple Fank			0			

and the set of the set of the		Descr	puve Sentiau	C4		
	N	Meaman	1st Guertile	Madian	3rd Quartier	
BG		56	83	228	388	90
UV2.0	6	0	0	Q	0	

Median Det Hank Sumit Hank sumit prviside breet en ve upper 90% 227 50 100.0 36.5 0.000 75.00 396.00

		metera	-				
Analysia	2 Sample Hark	Ho Median Diri .	0	0			
		Ha Not equal to 0		0			
Input Column 2	UV1-a	Cuntickence	-	09			
		De	acriptiv	e Statisti	-		
	N	Manimum	tal	Quartes	Median	3rd Quartile	Maximum
C-a	100		0	0	0	0	0
UV1-#			0	0	0	0	0
		Menn-White					
Median Diff.	Rank Sum1	Rank Sum2				rbbel 80%	
0.0	0 18.5			0 886	0.00	0.00	
0.0	10.5				trees, service of the local		
C-a v. UV2-a							
C-a v. UV2-a	Para	mellers					
C-a v. UV2-a Analysis	Para 2 Sample Rank	meters Ho: Median Dth. =		0			
C-a v. UV2-a Analysis Input Column 1	Para 2 Satripie Rarià C-s	meters Ho: Median Difi. = Ha: Not equal to 0		60			
C-a v. UV2-a Analysis	Para 2 Satripie Rarià C-s	meters Ho: Median Dth. =		09			
C-a v. UV2-a Analysis Input Column 1	Para 2 Satripie Rarià C-s	meters Ho: Kleckan Dift. = Ha: Not equal to û Confidence	E				
C-a v. UV2-a Analysis Input Column 1	Para 2 Sample Rasik C u UV2-a	meters Ho: Kleolain Dth. = Ha: Not equal to û Confidunce 	scriptiv	e Statiet		3rd Quartie	Maximum
C-a v. UV2-a Analysis Input Column 1	Pera 2 Sample Rank C u UV2-a N	meters Ho: Kleckan Dift. = Ha: Not equal to û Confidence	scriptiv				

Mann-Whitney Hank Analysia Masian Det. Rank Sum1 Rank Sum2 prvaluar lower Io% upper 90% 0.00 720 84.0 0.721 0.00 0.00

		metere				
Analysis	2 Sample Rank	Ho: Meckan Ditt. = 0	D			
input Column 1	C-b	Ha: Not equal to D	0			
Input Column 2	UV1-b	Confidence	0.95			
		Dee	oriotive Statist	lice		
	N	MIDITUT	1st Quarter		3rd Quartile	
C-n			0 0	1.200	2,400	2,400
UV1-b			0 0	0	3	10
Median Diff. 1,195.0	Rank Sum1 0 21.0	Rank Sum2	p-value p-value 0 0.485	lower 95%	upper 95% 2,400.00	
1,195.0	21.0	Rank Sum2 15	p-value	lower 95%		
1,195.0 C-b v UV2-b	0 21.0 Pere	Rank Sum2 15	p-value 0 0.485	lower 95%		
1,195.0 C-b v UV2-b Analysts	21.0 Para 2 Sample Hank	Rank Sum2 15	p-value 0 0.485	lower 95%		
1,195.0 C-b v UV2-b	Pera 2 Sample Flank C-b	Rank Suit2 15 meters]Ho: Median Dift = 0	p-value 0 0.485	lower 95%		
1,195.0 C-b v UV2-b Analysts input Column 1	Pera 2 Sample Flank C-b	Rank Sum2 15 He: Median Dift = 0 He: Not equal to 0 Confidence		iower 95% -10.00		
1,195.0 C-b v UV2-b Analysts input Column 1	Pera 2 Sample Flank C-b	Rank Sum2 15 He: Median Dift = 0 He: Not equal to 0 Confidence	p-value 0 0.486	10.00	2,400.00 3rd Quantile	Maxamurin
1,195.0 C-b v UV2-b Analysts input Column 1	Para Para 2 Sample Rank C-0 UV2-0	Rank Sun2 15 meters Ho: Median Diff = 0 Ho: Median Diff = 0 Confidence Deal	p-value 0 0.486	tice Median	2,400.00	Maximum 2,400

Median Def. Rank Sum1 Rank Sum2 p-value lower 95% upper 95% 0.00 78.0 60.0 0.442 0.00 2.400,00

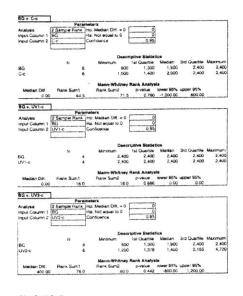
		meters					
Analysis	2 Sample Rank	Ho: Median Diff		0			
		Ha: Not equal to 0	L	0			
Input Column 2	UV2-0	Confidence	L	0.95			
	L	1					
		De	ecris	tive Statisti	Cé		
	N	Meramum	1		Median	3rd Quartile	Maximum
UV1-a			0	0	0	0	
UV2-8	2		0	0	0	0	
		Menn-White					
Median Diff.	Rank Sum1	Rank Sum2		p-value	kower 95%	upper 95%	
0.00	18.0		8.0	0 886	0.00	0.00	
UV1-6 v UV2-6	Para	meters					
	Para 2 Sample Hank UV1-b		• [0 0 0 95			
UV1-b v UV2-b Analysis Input Column 1	Para 2 Sample Hank UV1-b	meters Ho: Median Diff. = Hs: Not equal to 0 Contidence	° [0 0 95			
UV1-b v UV2-b Analysis Input Column 1	Para 2 Sample Hank UV1-b	meters Ho: Median Diff. = Hs: Not equal to 0 Contidence	° [0 95 0 95 ptive Statist	Median	3rd Quartie	
UV1-b v UV2-b Analysis Input Column 1	Pera 2 Semple Hank UV1-b UV2-b N	nesers Ho: Median Diff. = Ha: Not equal to 0 Contidence De Minimum	° [0 0 95 ptive Statiat 1at Guartie G	Median	3	1
UV1-b v UV2-b Analysis Input Column 1 Input Column 2	Para 2 Sample Hank UV1-b UV2-b	nesers Ho: Median Diff. = Ha: Not equal to 0 Contidence De Minimum	° [0 95 0 95 ptive Statist	Median	3	1
UV1-b v UV2-b Analysis Input Column 1 Input Column 2 UV1-b	Pera 2 Semple Hank UV1-b UV2-b N	Metiers Ho: Metian Diff. = His: Not equal to 0 Contidencia Minimum Minimum		0 0 95 ptive Statiat 1et Quartile C 0 Rank Aneiya	Median (3	1
UV1-b v UV2-b Analysis Input Column 1 Input Column 2 UV1-b	Para 2 Sample Park UV1-b UV2-b N Plank Sun1	Instants His: Mercian Diff. = His: Not equal to 0 Contidence De Minimum Mann-Whitt Rank Sum2		0 0 95 ptive Statiat 1at Quartile G 0 tank Aneiya p-value	Median (() la kower 95%	3 0 upper 95%	

5-nour Mann-Whitney test (Total Coliforms)

	Param	at and a				
Aneives		to: Median Dift = 0	0			
Input Column 1		a Not equal to 0	0			
		Confictence	0.95			
Input Calumn 2						
		Descr	ptive Statial	10.		
	N	Minimum	1st Quartile	Median	3rd Quartie	
BG		600	1.300	1,900	2,400	
C-a		5	16	48	1,175	2,400
G-8	S					
		Mann-Whitney	Rank Analys	i.e		
Median Drff	Banx Sum1	Rank Sume	p-value	KANNE 95%	upper 95%	
1.350.00		48.0	0.038	0.00	2,365.00	
	Param		0			
Analysis input Column 1 input Column 2	2 Sample Rank BG	eters Io: Mecian Diff. = 0 ta: Not equal to 6 Confidence	0 0.95			
Analysis Input Column 1	2 Sample Rank BG	to: Meclain Diff. + 0 ta: No: equal to 0 Confidence Descr	Iplive Statis	lica		
Analysis input Column 1 input Column 2	2 Sample Rank BG	to: Mecian Diff. = 0 ta: Not equal to 6 Confidence	Iplive Statis	Median		
Analysis input Column 1 input Column 2	2 Sample Rank BG UV1-8	to: Meclain Diff. + 0 ta: Not equal to 0 Confidence Descr	iplive Statis	Median 2,400	2.400	2 400
input Column 1 Input Column 2	2 Sample Rank BG UV1-8	to: Meclain Diff. + 0 ta: Not equal to 0 Controence Descr Missionum	tplive Statis 1st Ousrtim 2,400	Median 2,400	2.400	2 400
Analysis input Column 1 input Column 2 BG	2 Sample Rank BG UV1-8	to: Mecian Diff. = 0 ta:: Not aqual to 0 Controlence Descr Metimum 2,400 30	tplive Statis 1et Ousrtim 2,400 185	Median 2,400 280	2.400	2 400
Analysis input Column 1 input Column 2 BG	2 Sample Rank BG UV1-8	to: Mecian Diff. + 0 tic: No: equal to 0 Controance Descr Minimum 2,400 30 Menin-Whitney	Iplive Statis 1st Quartine 2,400 155 Rank Analys	Median 2,400 280	2.400 323	2 400
Analysis input Column 1 input Column 2 BG	2 Sample Rann BG UV1-8 N 4	to: Mecian Diff. + 0 sic: Not equal to 0 contrance Minimum 2,400 30 Menn-Whitney Fierk Sum?	tplive Statis 1st Quartile 2,400 18d Rank Analyt p-value	Median 2,400 280 Ise Kower 95%	2.400 323	2 400 330

BG V (V)2-1 Parameter Churyse [Sample Facts for weather weather of the open of the complexity of th

	Dare	Voutors				
Analysis		Ho Medan Ditt	0	1		
	BG	Ha Not equal to 0	0	£		
Input Column 1		Confidence	0.95			
Input Column 2	C-0	Confidence	0.03	2		
		-				
			criptive Stalls			
	1997	Minimum	1 at Quartie		3rd Quartie	Maxm.m
	N		00 1300			
BG	2	8 8	0 1300			
C-0	3	5	0 83	215	-	.,
		533 - TESS - TES	10000	1.0		
	1112-1112-11-20 States		ey Rauk Analys	ale internet	upper 95%	
Median Diff	Rank Sum1	Hank Sum2	p-value 0.038		2,240.00	
1,185.00	58	48	C 0.038	0.00	2,240.00	
BG v. UV1-b	1					
		meters				
Anatysis		His Median Dill. = 1	0 0	1		
Input Column 1		Its. Not equal to 0	0			
Input Column 2	UV1-b	Contidence	0.95			
		Det	criptive Statis		on en	an and
	N	Minimum	1st Quertile			
BG		4 2,4			2,400	2.400
1JV1-0			10 223	1.330	2,400	2 400
011-0		×			R., 400	
071-6		Mann-Whitne	ry Rank Analys	ala .		
Median Diff	Rank Sumi)	Mann-Whitne Hank Sum2	y Rank Analys	kower 95%	upper 95%	
		Mann-Whitne Hank Sum2	ry Rank Analys	kower 95%		
Median Diff		Mann-Whitne Hank Sum2	y Rank Analys	kower 95%	upper 95%	
Median Diff 1,070 00		Mann-Whitne Hank Sum2	y Rank Analys	kower 95%	upper 95%	
Median Diff 1,070 00		Mann-Whitne Hank Sum2 0 14	y Rank Analys p-value 10 0.343	kower 95%	upper 95%	
Median Difl 1,070 00 BG v. UV2-b		Mann-Whitne Hank Sum2 0 14	ny Rank Analyn p-villue 10 0343	kower 95% 0.00	upper 95%	
Median Diff 1,070 00 BG v. UV2-b Analysis		Mann-Whitne Hank Sum2 0 14	y Rank Analys p-value 10 0.343	kower 95% 0.00	upper 95%	
Median Diff 1,070 00 BG v. UV2-b Analysis input Column 1	22 Par 2 Samper Fant BG	Mann-Whitne Hank Sum2 0 14 ametars]Ho: Median Diff. + 1	ny Rank Analyn p-villue 10 0343	is lower 95% 0.00	upper 95%	
Median Diff 1,070 00 BG v. UV2-b Analysis	22 Par 2 Samper Fant BG	Mann-Whitne Hank Sum2 0 14 ameters Ho Mechan Diff. a Ho: Not equal to 0	y Rank Analys p-value 0 0.343	is lower 95% 0.00	upper 95%	
Median Diff 1,070 00 BG v. UV2-b Analysis input Column 1	22 Par 2 Samper Fant BG	Mann-Whitne Hank Sum2 0 14 ameters Ho Mechan Diff. a Ho: Not equal to 0	y Rank Analys p-value 0 0.343	is lower 95% 0.00	upper 95%	
Median Diff 1,070 00 BG v. UV2-b Analysis input Column 1	22 Par 2 Samper Fant BG	Mann-Whitn Hank Sum 0 14 amelers Ho, Mechan Diff. a Ha: Not equal to 0 Gonficence	y Rank Analys p-value 0 0.343	iowar 95% 0.00	upper 95%	
Median Diff 1,070 00 BG v. UV2-b Analysis input Column 1	22 Part 2 Samper Fants BG UV2-b	Mann-Whitm Hank Sum2 0 14 ameters Ho, Median Diff. + Ha: Not equal to 0 Confidence Dec	Py Rank Analys p-value 10 0.343	kower 95% 0.00	upper 95% 2,290.00	Maximum
Median Diff 1,070 00 BG v. UV2-b Anarysis Input Column 1 Input Column 2	22 Par 2 Samper Fant BG	Mann-Whith Hank Sum2 0 14 emeters Ho Meden Diff. n Ho: Nedean Diff. n Ho: Nedeau to 0 Confidence Manimum	ey Rank Analys p-value 10 0343	kis kower 95% 0.10 0.10	upper 95% 2,290.00 3rd Quartile	
Median Diff 1,070 00 BC v. UV2-b Analysis Input Column 1 Input Column 2 BG	22 Par 2 Samper Rank BG UV2-b N	Mann-Whitn Hank Surn2 0 14 Ho: Machan Diff. + Ho: Not equal to 0 Confloence Minimum 8 6	ey Rank Analys p-vsiue 10 0 343 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	kia kower 95% 0.100 vitica Median 1 900	2,240.00 3rd Quantile 2,400	2.400
Median Diff 1,070 00 BG v. UV2-b Anarysis Input Column 1 Input Column 2	22 Par 2 Samper Rank BG UV2-b N	Mann-Whitn Hank Surn2 0 14 Ho: Machan Diff. + Ho: Not equal to 0 Confloence Minimum 8 6	ey Rank Analys p-vsiue 0 0 343 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	kia kower 95% 0.100 vitica Median 1 900	2,240.00 3rd Quantile 2,400	2.400
Median Diff 1,070 00 BC v. UV2-b Analysis Input Column 1 Input Column 2 BG	22 Par 2 Samper Rank BG UV2-b N	Mann-Whitm Hank Sun2 0 14 ameteri Ho Median Diff, a Ha Nol squai to 0 Confloence De Maimum 8 6	ey Rank Analys p-vsiue 10 0343 0 00 0 00 0 095 scriptive Statis 1st Guartie 00 1,300 35 56	tion Median 1 900 1 900 1 900	2,240.00 3rd Quantile 2,400	2.400
Median Diff 1,070 00 BC v. UV2-b Analysis Input Column 1 Input Column 2 BG	22 Par 2 Samper Rank BG UV2-b N	Mann-Whitm Hank Sun2 0 14 ameteri Ho Median Diff, a Ha Nol squai to 0 Confloence De Maimum 8 6	ey Rank Analys p-vsiue 10 0 343 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	tion Median Median 1900 1900 1900 1900 1900 1900 1900	2,240.00 3rd Quantile 2,400	2.400



5-hour T-test (E.coli)

	Para	maters				
An alysia	2 Sample t	Ho: Mean Diff. = 0	0			
nout Calumn 1	BG	Ha: Not equal to 0	0			
nput Column 2	C-8	Contidence	0.9			
		Pooled Variance	FALSE			
		Descriptive Stat	Istics			
	N	Mean	Sid Dev.	Std Err.		
BG	8	293 68	285.067	100.785		
C-8		0.63	1.758	0 825		
			Test Analy			
Mean Ddf.	Std. E.m.	£	at	p-value	lower 90%	upper 90%
				0.023	102 30	484.20

Input Column 2	UV1-a	Contidence	0.95		
		Poosed Vanance	FALSE		
		Descriptive Sta	tistics		
		Descriptive an	Std. Dev	Stot. Err	
BG		4 505.25		132 140	
90					
		4 0.06	0.000	0.000	

1-Test Analysis 1 dl p-vsius Iower 95%, upper 95%, 3.824 3.00 0.031 84.72 925.75 Mean Diff. Sto. Err. I 505.25 132 140

BG v. UV2-a

UV1-a

Analysia		HO: Mean Diff = 0	0			
input Column 1	BG	Ha: Noi nguar to 0	0			
Input Column 2	JV2-8	Contiounce	0.95			
		Pooled Vanahce	FALSE			
		Descriptive Stat	latic a			
	N	Mean	Std Dev.	Std En.		
BG		293.88	285.067	100.786		
UV2-8		û 00	0.000	0.000		
0.45.8			0.000	0.000		
		ŀ-	Tosl Anely	215		
Mean Diff.	Sta En	· ·	di di		lower 95%	upper 95%

	Peret	voloce					
Analysis	2 Sample Rank	so Median Diff.	• 0 F	0			
Input Column 1	Ca	Ha: Not equal to		0			
Input Column 2		Contidence	C	0.95			
				ptive Statis			
	N	Manamum		1st Quartile		3rd Quartile	
C-e	4		60	795	1,310	1,785	
UV1-+	4		30	108	260	323	33
				lank Analys			
Madean Diff.	Rank Sum1		-	p-value	kowar 95%	upper 95%	
	23.0		13.0	0.200	-270.00	2,370.00	
C-a v. UV2-a Parametere Araiysis Input Column 1 Input Column 2	2 Sampie Rank	rio: Median Dift. Ha: Not equal to Confidance	•	0 0 0.95			_
C-a v. UV2-a Parametere Araiysis Input Column 1 Input Column 2	2 Sampia Rank C-a IIV2-a	rio: Median Dift. Ha: Not equal to Confidance	•	0 0 0.95	Meduari	3rc Quartile	Maxmur
C-a v. UV2-a Parametere Araiysis Input Column 1 Input Column 2	2 Sampie Rank C-a UV2-a	no: Median Diff. Ha: Not equal to Confidance	* ° [0	0 0 0.95 1at Guartile 16	Meduari 48	3rd Quartile 1,175	Maxmur 2,40
C-a v. UV2-a Perseneters Analysis Input Column 1 Input Column 2 De	2 Sampie Rank C-a UV2-a	no: Median Diff. Ha: Not equal to Confidance	• • [0 0 0.95 1at Guartile 16	Meduari 48	3rd Quartile 1,175	Maximur 2,40
C-a v. UV2-a Parametara Avarasi Input Column 1 Input Column 2 De C-a UV2-e Mann-1	2 Sampie Renk C-a IUV2-e ecriptive Statistic N 8 6 Whitney Rank An	no: Median Dift. Ha: Not equal to Confidence Se Missence Missence alysis	5 C	0 0 0.95 1at Ouartile 16 24	Merduari 48 38	3rd Quartile 1,175 228	Maximur 2,40
C-a v. UV2-a Parametara Avarasi Input Column 1 Input Column 2 De C-a UV2-e Mann-1	2 Sample Rank C-a IIV2-a ecriptive Statistic N 8 6	no: Median Dift. Is: Not equal to Confidence Beneficience Minertum Sense Sum2	5 C	0 0 0.95 1at Quartile 16 24 0-velue	Merdean 48 38 kower 95%	3rd Quartile 1,175	Meximur 2,40

BG v. C-b Paramaters Analysis Input Cournen 1 BG isa: Not exuals to 0 Input Cournen 2 C-b Confidence Poceno Vanance FALSE

BG v. UV1-b.
Parametere
Analysis
2 Sample 1 Ho. Nean Off = 0
input Coumn 1 BG
Input Conterno
Pooled Vanance
FALSE
FALSE

BG v. UV2-b Parameters Analysis 2 Sample 1 Ho Mean Diff. = 0 0 Input Column 2 UV2-b Conteince Poceed Vanance FALSE

 Descriptive Statistics

 N
 Mean
 Sat. Cwv. Std. Err.

 8
 293.88
 265.067
 100.796

 8
 600.00
 1,110.984
 362.792

 Descriptive Statistics

 N
 Mesen
 Std. Dev. Std. Err.

 4
 505.25
 264.279
 132.140

 4
 2.50
 5.000
 2.500

 Bits
 Statustics

 N
 Maxen
 Stat
 Dev
 Stat
 Err.

 8
 293
 85
 285
 OF
 100
 786

 6
 0.00
 0.000
 0.000
 0.000
 0.000

I- feel Analysis
 If feet Analysis

 Mean Diti
 Std. Err
 1
 dt
 p-vacas
 kower 90% upper 90%

 293.86
 100.786
 2.918
 7.00
 0.022
 102.93
 464.62

 Hear Drff
 Sid. En
 1 Test Analysis

 Mean Drff
 Sid. En
 0
 p-velue
 kowof 90% upper 90%

 502.75
 122.163
 3.804
 3.00
 0.032
 191.72
 513.78

 I-Test Analysis

 Mean Dett
 Std Err.
 t
 dt
 p-reuse towar 60% upper 90%

 -306 13
 405 516
 -0.755
 7.92
 0.475
 -1,074 41
 462.16

BG v. C-b

8G C b

BG V UV1-b

BG UV1-b

BG UV2-0

BG v. UV2-b

	His: Median Dift. = 0 His: Not equal to 0 Confidence	0.95				Analysis Input C Input D
e Statist	ics Minimum	1at Quartile	Median	3rd Quartile	Maxmum	
8		5 16	48	1,175	2,400	C-6
6		0 24	38	228	1,010	UA5-P
Beak A	naivala				1	

Perameters Anarysis Input Column 1 Input Column 2	2 Sample Rank C-c UV1-b	Ha: Median Ditt He: Nai equal to Confidence		0 0 0.95			
D	ascriptive Statist						
	N	Manamum		1at Quartile		3rd Quarthe	
C-0	4		270	368	1,400		
uV1-b	4		110	223	1.330	2,400	2,400
Mann	Whitney Rank A						
Median Diff.	Hank Sum1	Flank Suma	£	p-value			
5.00	20.0		16.0	0.686	-2,130,00	2,290.00	
C-b v. UV2-b Parameters Analysis Input Column 1 Input Column 2	CL	Ho Median Diff. Ha Not aqual to Confidence		0 0.95			

Asscriptive Statistics N Minimum Ist Quartie Mediani 3rd Ouentie Meximum 8 0 93 215 900 2,400 8 35 56 93 275 2,400 Menn-Whitney Rank Analysia Median Dati Hank Sumt Rank Sum2 prease lower 95% upper 95% 97.50 79.5 56.5 0.257 -80.00 2.070.00

	Para	melers				
Analysis	2 Sample Rank	Ho: MeGan Ditt. = 0	0			
Input Column 1	UVI-a	Ha: Not equal to 0	0			
Input Column 2	UV2-8	Contidence	0.95			
		Descr	iptive Statis	lics		
	N	Minimum	1st Guartrie	Median	3rd Quartie	Maxmum
UN1-a		30	188	280	323	330
UV2-a	2	290	470	650	830	1,010
		Mann-Whitney				
Meckan Dell.	Rank Sum1					
30.00	20.0	16.0	0.665	-980.00	530.00	
UV1-6 v. UV2-E		malara				
Analysis Input Column 1	Pare 2 Sample Rank 1/V1-b	matera Ho: Median Ditt. + 0 Ha: Not equal to 0 Confidence	0 6 0.95			
Analysis Input Column 1	Pare 2 Sample Rank 1/V1-b	Ho: Median Diff + 0 Ha: Not equal to 0 Confidence Descr	0 0.95 liptive Statler	lice		
input Column 1 Input Galumh 2	Pare 2 Sample Rank 1/V1-b	Ho: Median Diff + 0 Ha: Not equal to 0 Confidence Descr Minimum	0 0.95 iptive Statle 1st Quarbie	lica Mediar	3rd Quartile	
Analysis Input Column 1 Input Golumn 2	Para 2 Sample Rank UV1-b UV2-b	Ho: Median (241 + 0 Ha: Not equal to 0 Confidence Descr Minimum 110	0 6 0.95 iptive Statia 1st Quarbie 223	lica Median 1,330	3rd Quartile 2,400	2 400
Analysis Input Column 1 Input Golumn 2	Para 2 Sample Rank UV1-b UV2-b	Ho: Median Diff + 0 Ha: Not equal to 0 Confidence Descr Minimum	0 0.95 iptive Statle 1st Quarbie	lica Median 1,330	3rd Quartile 2,400	2 400
Analysis Input Column 1 Input Golumn 2	Para 2 Sample Rank UV1-b UV2-b	Ho: Median Diff + 0 He: Not equal to 0 Confidence Descr Montrum 110 330 Mann-Whitney i	0 0.95 iptive Statia 1s: Ouarbie 223 848 Rank Anatys	lica Median 1,330 1,365	3rd Quartile 2,400 1,843	2 400
Analysis Input Column 1 Input Galami 2 UV1-b UV2-b	Pare 2 Sample Hank 1/V1-b UV2-b N 4 2 Pare Sum1	Ho Median Diffi + 0 He Not voue to 0 Confidence Monimum 110 330 Mann-Whitney 1 Hans Sum2	0 0.95 iptive Statist 1s: Ouarbie 22/3 848 848 Rank Analys	lica Mediar 1,330 1,365 ia iower 96%	3rd Quartile 2,400 1,843	2 400

	Pararne	inra				
Arseryala	2 Sample 1 Into	. Meen Dit + 0	0			
Input Column 1	BG Ha	Not equal to 6	0			
INDUIT COMMINS 2	Cc Cc	onticence	095			
0.00	Po	wind Vanance	FALSE			
			he reasons where the			
		Descriptive Sta	tistics			
	•	Descriptive Sta	tistics Std Dev.	510. En.	~~~~~~	
BG	۰ ۲	Mean	Std Dev.	510. En. 100.785		
BG Ca		Mean 293.68	Std Dev. 285.067	100.785		
BG C 4		Mean 293.68	Std Dev.	100.785		
		Mwan 293.68 979.38	Std Dev. 285.067	418.659		
		Mwan 293.68 979.38	Std Dev. 285.067 1,184.798	100.785 418.659	Kower 55%	upuer \$5%

	Paramet	ara .				
Analysis	2 Sampel Ho	Mean Diff. = 0	0			
mout Column 1	86 14	Not equal to 0	0			
Input Column 2	UVI-C CO		0.95			
	Po	wed Vanance	FALSE			
		Descriptive Stat	Intica			
	N		Std Dev	Std En		
BG				132 140		
UVI-c	-			480 000		
		ŀ	Test Anal	vala		
Mean Diff.	Std Err.	1	a	p-value	IOW #1 95%	upper 95%
	497.856	2.842	3.45	0.066	-2.999 15	169 65
BG v UV2-c	Paramet	ers				
BG v. UV2-c Analysis input Column 1 input Column 2	2 Sampler 1 Ho BG Ha UV2-C Co	ers Mean Diff 0 Not equal to 0 nictence olec Vanence	0 0.95 FALSE			
Analysis Inpus Column 1	2 Sampler 1 BG Ha UV2-c Co Po	Mean Diff 0 Not equal to 0 nitoence olec Variance Descriptive Stat	095 FALSE			
Analysis input Column 1 input Column 2	2 Sampler 1 Ho BG Ha UV2-C Co	Mean Diff. = 0 Not equal to 0 nildence over: Variance Descriptive Stat Mean	095 FALSE			
Analysis input Column 1 Input Column 2 BG	2 Surrigher I Ho BG Ha Liv2-c Co N 8	Mean Diff. = 0 Not equal to 0 nitioence over: Vanence Descriptive Stat Mean 293.88	095 FALSE SIG Cav 285.06/	100 788		
Analysis input Column 1 input Column 2	2 Sampler 1 BG Ha UV2-c Co Po	Mean Diff. = 0 Not equal to 0 nitioence over: Vanence Descriptive Stat Mean 293.88	095 FALSE SIG Cav 285.06/			
Analysis Ingua Column 1 Ingua Column 2 BG UV2 c	2 Samper 1 Ho BG LIV2-c Co N 6 5	Mean Diff 0 Not equal to 0 nitidence olac: Variance Descriptive Stat Moan 293.88 109.17	095 FALSE Sid Dev 285.067 122.042	100 786 49 823		
Analysis input Column 1 Input Column 2 BG	2 Surrice 1 Ho BG Ha UV2-C Co N 6 5	Mean Diff 0 Not equal to 0 nitoence ole:: Variance Descriptive Stat Muan 293.88 109.17	0.95 FALSE SIG Cev 285.067 122.042	100 788 49 823 yaie p-value	65.60	

	Pare	mellera				
Analyse	2 Sample I	His Mean Det = 0	6			
Fout Courses 1	G-a	Ha Not equal to 0	0			
Input Column 2	UVI-a	Conhowice	0 95			
		Pooled Variance	FALSE			
8						
		Descriptive St				
	N	Mean	Sig Dev	Sta En		
Ca	4	0.00		0.000		
UV1-w	4	0.00	0.000	0.000		
			I-Test Anal	rois		
Meen Diff.	Std Err.	£	đ	p-value	KOWINY 35%	upper 95%
6 00	0.000	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE
C-e v. UV2-e						
		meters				
Analysia		Ho Mean i'm = 0	0			
Input Column 1		HE. NOI BUT IN	0			
Input Column 2	11/V2-6	Contidence	0.95			
		Pooled Variance	FALSE			

		Descriptive Sta	lintics				
				Pr 1 1 1			
	N	Maan	Std Dev.	5td Err			
C-a	5	0 53	1.768	0.625			
UV2 a	6	0.00	0 300	0 500			
			Tasl Anel	vala			
Mean Diff.	SAJ. EM	1	ď	D-velue	IOM UT 95%	upper 1	95%
0.63	0.625	1.007	7.00	0.351	-0.85		2 16

	_
\subset	
1	5
U	-

	Peram					
Analysia	2 Sample 1	to: Mean Ditt. = 0	0			
Input Column 1		ta: Not equal to 0	0			
Input Column 2		Conlidence	0.95			
		Pooled Vanance	FALSE			
		Descriptive Stat	intic a			
	N	Meato	Std. Dev.	Std. Err.		
C-0			1,385.641			
UN1-b	3	2.50				
071-6		1.00				
		1	Test Analy	wis .		
Maan Drff.	Sto. En		df		lower 95%	
	692 825	1 728	3.00	0.182	-1.007.38	3.402.38
and the second se						
C-b v. UV2-b						
and the local de la company		meters				
Analysis	2 Sample 1	Ho Muan Diff. = 0	0	1		
Analysis Input Column 1	2 Sample 1 C-b	Ho: Mean Diff. = 0 He: Not equitil to 0	0			
C-b v. UV2-b Analysis Input Column 1 Input Column 2	2 Sample 1 C-b UV2-b	Ho: Mean Diff. = 0 He: Not equil to 0 Contidence	0.95			
Analysis Input Column 1	2 Sample 1 C-b UV2-b	Ho: Mean Diff. = 0 He: Not equitil to 0	0.95 FALSE			
Analysis Input Column 1	2 Sample 1 C-b UV2-b	Ho: Mean Diff. = 0 He: Not equil to 0 Contidence	FALSE	1		
Analysis Input Column 1	2 Sample 1 C-b UV2-b	Ho: Maan Diff. = 0 Ha: Not equit to 0 Contidence Pooled Variance Descriptive Stat Mean	FALSE bistics Sid. Dev.	Std. Err.		M
Analysis Input Column 1	2 Sample I C-b UV2-b	Ho: Maan Diff. = 0 Ha: Not equit to 0 Contidence Pooled Variance Descriptive Stat Mean	FALSE	Std. Err. 392 792		

.

BC V. C-C
Parameters
Anaryse
2 Surges 11 Ho: Mean DB1 = 0
3
Hourd Calumn 1
EC
Pooled Variance
FALSE

Mean Diff Stul Err.

BG C-c

600.00 392.792

1-Test Anelysis or p-value lower 95% upper 95% 1.528 7.00 0.170 -328.81 1.528.81

	Para	melers							
		Ho: Mean Oft	-0	6					
Input Column 1		ha: Not equal	100	0 95					
input Column 2	JV2-a	Contraence	-	FALSE					
		Pooled Varies	ce L	PALSE					
		Descriptiv	s Stati	stice					
	N	Mean		Std. Dev					
UV1 a	4		0.00	0.000	0.000				
UV2-A	2		0 00	0.000	0.000				
			1-3	feat Analy					
Mean Dr.	Std. Em.	£		a	p-value				
0.00	0.000	#DIV/DI		IVALUE!	#VALUE!	#VAL	JE	#VA	UE
Input Column 1 Input Column 2	UV1-6 UV2-5	Ha Not equal Continence Pooled Vane		0 95 FALSE					
		Descriptiv	a Stat	stics	614 F.				
Second Second	N	Mean		Std. Dev 5.000					
UV1-b			2.50						
			0.00	0.000	5 000				
0.45-0					-sis				
0.15-0			1-	Test Analy					
Mean Diff	Std. En		1 000	đ	p-velue	-	95%	upper	955

C-# v. UV1-4

C-a

C-

Mean Ditt. Std. Etr.

C-. v UV2-.

 C-e v. UV1-a
 Parameters

 Anatyset
 2 Sampe 1
 Ho: Mean Diff = 0
 0

 Input Column 1
 C-e
 Ha: Not equal to 0
 C

 Input Column 2
 UV1-a
 Contrastice
 0 95

 Pould Column 2
 UV1-a
 Contrastice
 0 95

 C-a v
 UV2-e
 Parameters

 Analysis
 2 Sunce 1 ho Mean Diff. + 0
 0

 Input Column 1
 C =
 fra. Not equal to 0
 0

 Input Column 2
 UV2-a
 Contismos
 FALSE

 Pooled Varance
 FALSE
 FALSE
 FALSE

N

Mean Diff Std. Err

410.63 365.869

 Descriptive Statistics

 N
 Mean
 Sul. Dev
 Sul. Err.

 4
 1.270.00
 981.495
 490.748

 4
 230.00
 139.284
 642

 I-Text Analysis

 Aven Ditt.
 Std. Err.
 rt
 p value
 jower 95% upper 95%

 1,040,00
 455.665
 2.096
 3.12
 0.127
 -537.43
 2,617.43

 Descriptive Statistics

 Mean
 Stat Dev.
 Stat. Err

 5
 643.13
 928.470
 328.264

 6
 232.56
 395.749
 161.564

1-Test Anerysis 1 of p-value lower 95% upper 95% 1.122 9.98 0.261 -417.03 1.236.28

		mela/s		
		Ho: Mean Dift. = 0 Ha: Not equal to 0 Considence Housed Variance	0 0 95 FAI SE	
		Descriptive Stat	atics	
	N	Maran	Std. Dev.	
BG		1,750.00	738.725	
				326.26

 I-trast Analysis

 Meari Dell
 Std Err
 1
 d*
 p=ratue
 kover 95% upper 95%

 1 106 66
 419-469
 2 639
 13 33
 0 020
 200 62
 2 013 13

 BG v. UV1-e
 Parameters

 Analyse
 2 sanzymi 1 Hot. Meet Ditl = 0
 0

 anyur Courren 1
 BG
 res. Not equal to 0
 0

 by ur Courren 2
 UV1 a
 Containce
 0.05

 Hopd Courren 2
 UV1 a
 Containce
 FALSE

 Descriptive Statistics

 N
 Mean
 Std Dev.
 Sid Err.

 4
 2:400 00
 0:000
 0:000

 4
 2:30:00
 139:284
 69:642
 BG UV1-a

1-Test Analysia Mean Dift Std.Em. t of p⊸value lower/95% upper96% 2,170.00 69.642 31.155 3.00 0,060 1,548.37 2,391.63

 BC // 07-4
 Paramaters

 Anarys
 Sample 11-6

 Vec/ Caurret 1
 Br.

 Pound Caurret 1
 Br.

 Pound Caurret 1
 Br.

 Pound Caurret 2
 Colored Caurret 2

 Pound Caurret 2
 Colored Caurret 2

 Descriptive Statistics

 N
 Mean
 Sid Dev.
 Sid. En.

 8
 1.750.00
 738.725
 261 179

 6
 232.50
 365.749
 161.564
 BG UV2-s

1-Test Analyses Mean Diff Sid En. 1 of p-values lower 95% upper 95% 1-517 50 307 111 4 941 11 11 0 500 841 55 2 15/45

C-0 . 0V1-0

		ameters			
Analysis Input Column 1 Input Column 2	C-b	Ho: Mean Diff + 0 ria: Not equal to 0 Confidence Pooleo Vanance	0 0.95 TRUE		
		Descriptive Stat	totice.		
	N	Mean	Sig Dere	Std. En	
0-0	2001	1.367.50	1.193 405	596.704	
UV1-D		4 1,292 50	1,280.296	840.148	
			Test Analy	win .	

Mean Diff Std. Err. 1 75.00 875.126 t 02 p-value Lower 95% upper 95% 0.086 6.00 0.934 2,066.36 2,216.36

 C-b-v
 UV2-b

 Anaryes
 Z Sample 1

 Input Column 1
 C-b-v

 Input Column 2
 Confidence

 0.95
 Confidence

		Descriptive Stat	anti-ca			
	N	Merbill	Std Dev	Sid. En		
C-5		722.50	1,043.083	388.785		
UV2-0	6	500.00	937 054	382.551		
		ŀ	Test Analy	615		
Mean Diff.	Sta. En	1	đ		kower 95%	upper 95
222 50	540 208	0.412	12 00	0 666	-954 51	1,399

 BG v. C-5
 Perameters

 Aralytia
 2.5errole:
 to Meen DEI = 0

 Juga Column 1
 BG
 tra. Nu equal to 0
 0

 Input Column 1
 C-0
 Continence
 0.93

 Proced Venence
 FAI SE
 FAI SE
 BG v. C-6 Descriptive Statistics Mean Stil Dev Std. Err. 1,750.00 738 725 261 179 722.50 1,043 083 368 785 N ~ BG C-b Frest Analysis
 Mean Diff. Skii Err. 1 of p-value lower 95% upper 95%
 1027 50 451,904 2 274 12,81 0,042 42,86 2,012,11 BG v. UV1-b
 BG v. UV1-b
 Parameters

 Analysis
 2 Sample 1
 ho: Most Diff. = 0
 0)

 Input Galumn 1
 BG
 Hs: Not equal to 0
 0)
 0)

 Input Galumn 2
 UV1-b
 Constaence
 0
 0
 0

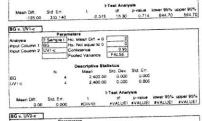
 Input Galumn 2
 UV1-b
 Constaence
 FALSE
 FALSE
 FALSE
 Descriptive Statistics N Mean Sto Dev Std. En 2 2,400.00 0.000 0.000 4 1,292,50 1,280 296 640.148 BG UV1-b 1-Test Analysia Maen Drift Skil En 1 d* p-value loeur 855-upper 955-1.107.50 540,148 1.730 3.00 0.182 -4226,74 3.144.74 Descriptive Statistics Mean Std Dev Std Err. 8 1,750.00 /38.725 261.179 6 500.00 937.054 382.551 82 BG UV2-b I-Test Analysia dt p-valus lower 55% upper 95% 2,699 9.30 0.024 202.16 2.297.84 Mean Diff Std Err 1,250.00 465.205 ¥2. . UV1-a v UV2-a Personaters Analysis Ingus Column 1 UV1-a Ingus Column 2 UV2-a CostCourse Huyed Vanance FALSE UV1-a v. UV2-a

Descriptive Statistics Mean: Std Dev. Std Err 230.00 159.284 69.642 650.00 509.117 380.000 N M 4 2 UV1-8 UV2-8

1-Teet Analysis dt p-value tower 95% upper 95% -1 145 1.08 0.457 -5,079.02 4.239.02 Mean Diff Std. En 420.00 366 674

		inelers.			
Analysis		Ho Mean Diff. = 0	0		
Input Column 1		Ha: Not equal to 0	0		
Input Column 2	LV2-6	Conficience	0.95		
		Pooled Variance	FALSE		
		Descriptive Stat	atics		
	N	Medial	Std. Lev.		
UV1-0	4	1.292.50	1,280.296	640.148	
UV2-0	2	1 365 00	1,463.711	******	
			Test Analy		

Mean DM. Sid Err 1 dl p-value lower 95% upper 95% upper 95% 0060 1.82 0.962 -15.535.50 15.380.50



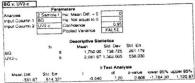
 Descriptive Statistics

 N
 Mean
 Std. Dev.
 Std. Err.

 8
 1.750.00
 738.725
 261.179

 6
 1.875.00
 584.930
 206.804

1.





1-day Mann-Whitney lest (E.coli)

BG v. C-s						
	Para	meters				
Analysia	2 Sampie Raux	Ho: Median Diff = 0	0			
input Column 1	BG	Ha: Not equal to 0	0			
neut Column 2		Conlidence	0.9			
and construct						
		Deport	ptive Statist	IC.		
	N	Minimum			3rd Quartile	Maximum
6G	14	2	13			
C-4	13	0	0	0	0	1
12 - Carlos and a second						
1		Mann-Whitney				
	Rank Sum*	Rank Sum2			upper 90%	
23.00	301.0	105.0	0.000	14.00	690.00	
BG v. UV1-e						
		meters	0			
Analysis	2 Sample Rank	Ho. Median Diff. = 0	0			
input Column 1		Ha: Not equal to 0				
nput Column 2	UV1-a	Confidence	09			
		2				
		Descri	iptive Statist	NO.		
	N				3rd Quartile	
BG	6	130	735			
UV1-8	8	0	0	٥	0	0
		Mann-Whitney	Our touch			
	Bank Sum1	Hank Sum2			upper 90%	
Median Diff.			0.000		1,700.00	
1,275.00	57.0	21.0	0002	000.00	1,700.00	
	1					
BG v. UV2-a	Deres					
		meters	0			
Analysis	2 Sample Rank	Ho: Median Dift = 0	0			
Analysis Input Column 1	2 Sample Rank BG	Ho: Median Dift = 0 Ha: Not equal to 0	0			
Analysis Input Column 1	2 Sample Rank BG	Ho: Median Dift = 0				
Analysis Input Column 1	2 Sample Rank BG	Ho: Median Dift = 0 Ha: Not equal to 0	0			
Analysis Input Column 1	2 Sample Rank BG	Ho: Median Diff: = 0 Ha: Not equal to 0 Confidence	0 0.9	ica.		
Analysis Input Column 1	2 Sample Rank BG	Ho: Median Diff: = 0 Ha: Not equal to 0 Confidence	0 0.9	Median	3rd Quarble	
Input Column 1 Input Column 2	2 Sample Rank BG UV2-a	Ho: Median Dift = 0 Ha: Not equal to 0 Confidence Descr Minimum	0 0.9	Median		
Analysis Input Column 1 Input Column 2 BG	2 Sample Rank BG UV2-a N	Ho Median Dift = 0 Ha: Not equal to 0 Conticence Minimum 2	0 0.9 Iptive Statist	Median 24	825	1,700
Analysis Input Column 1	2 Sample Rank BG UV2-a N	Ho Median Dift = 0 Ha: Not equal to 0 Conticence Minimum 2	0 0.9 tptive Statist 1st Quartie 13	Median 24	825	1,700
Analysis Input Column 1 Input Column 2	2 Sample Rank BG UV2-a N	Ho Median Dift = 0 Ha: Not equal to 0 Conticence Minimum 2	0 0.9 1ptive Statiat 1st Quartie 13 0	Mudian 24 0	825 0	1,700
Analysis Input Column 1 Input Column 2 BG	2 Sample Rank BG UV2-a N	Ho Median Diff = 0 Ha: Not equal to 0 Confidence Descr Minimum 2 0	0 0.9 1ptive Statiat 1st Quartie 13 0	Mudian 24 0	825 0 upper 90%	1,700

Analysia Input Calumn 1 Input Calumn 2		meters Ho: Median Diff. = (Ha: Nor equal to 0 Conficence	0 0 0			
		Der	scriptive Statis	lics		
	**	Munimum			3rd Guarola	
BG	14		2 13		825	1,700
C-b	14		0 0	0	2	/0
		Mano-White	y Rank Analy	ie.		
Mudan Diff.	Rank Sum1	Rank Sum2	p-value		upper 90%	
15.00	277 0	121	0.00:	12 00	690.00	
BG v UV1-b						
BG V. UV1-0						
Anathenia		meters Iso: Metern Off. w	0 0	1		
Input Column 1		meters Ho: Medium Dift + Hu: Not equal to 0 Contidence	0 0			
Input Column 1	2 Sample Bank BG	Ho: Median Off + Ha: Not equal to 0 Contidence	0.9			
Input Column 1	2 Sample Bank BG	Ho: Median Dift + Ha: Not equal to 0 Contidence Der Minemute	0.9 0.9 acriptive Statis	Median		
Analysis input Column 1 input Column 2 8G	2 Sample Bank BG UV1-b	Ho: Median Dift + Ha: Not equal to 0 Contidence Der Minemute	0.9 0.9 1st Quartile 30 735	Median 1.275	1,695	1,700
Input Column 1 Input Column 2	2 Sample Bank BG UV1-b	Ho: Median Dift + Ha: Not equal to 0 Contidence Der Minemute	0.9 0.9 acriptive Statis	Median 1.275		1,700
Input Column 1 Input Column 2	2 Sample Bank BG UV1-b	Ho: Mediam Dift w Ha: Not equatito 0 Contidence De Minimum 1	0.9 0.9 1st Quartile 30 735	Median 1.275 0	1,695 Ú	1,700
input Column 1 Input Column 2	2 Sample Bank BG UV1-b	Ho: Median Off = Ha: Not equal to 0 Contidence Manmus: 1 Mann-Whitm Rank Sum2	0.9 0.9 1st Quartie 30 735 C C sy Rank Analys p-value	Median 1.275 0	1,695 0 upper 90%	1,700
input Column 1 input Column 2 8G UV1-b	2 Sampis Harik BG UV1-b N 6 6 6 7	Ho: Median Off + Ha: Not equal to 0 Contidence Manmutri Mann-Whitm Rank Sum2	o 0.9 0.9 0.9 0.9 0.9 0.0 0.735 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	Median 1.275 0	1,695 0 upper 90%	1,700
Input Column 1 Input Column 2 BG UV1-b Median DM. 1,274.60	2 Sampis Harik BG UV1-b N 6 6 6 7	Ho: Median Off + Ha: Not equal to 0 Contidence Manmutri Mann-Whitm Rank Sum2	0.9 0.9 1st Quartie 30 735 C C sy Rank Analys p-value	Median 1.275 0	1,695 0 upper 90%	1,700
Input Column 1 Input Column 2 BG UV1-b Median DM. 1,274.60	2 Sampis Hanii BG UV1-b N 6 6 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Ho: Median Off # Ha: Not equal to 0 Controlence Der Minemuti 1 Mann-Whitte Rank Sum2 21	0.9 0.9 1st Quartie 30 735 C C sy Rank Analys p-value	Median 1.275 0	1,695 0 upper 90%	1,700
Input Column 1 Input Column 2 86 UV1-b Median Dff. 1,274.50 80 v. UV2-b	2 Sampis Hanii BG UV1-0 N 6 6 6 7 9 1 57 0 1 2 2 2 2 2 2 2 2 2 2 2 3 2 2 3 2 3 2 2 3 2 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 3 2 3 3 2 3 3 2 3	Ho: Median Dift + Ha: Noi equal to 0 Contioence Minemum 1 Mane-Whitin Rank Som? 2 meters	o o o o o o o o o o o o o o	Median 1.275 0 kower 90% 690.00	1,695 0 upper 90%	1,700
Input Column 1 Input Column 2 BG UV1-5 Madian DM. 1.274.50 BG v. UV2-5 Analysia	2 Sampis Racii BG UV1-b N 8 6 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Ho: Median Dift - ha: Noi equal to 0 Confidence Minemum Rank Sum2 2 meters [ho: Median Dift -	0 09 09 09 09 09 09 09 09 00 00 00 00 00	Median 1.275 0 kower 90% 690.00	1,695 0 upper 90%	1,700
Input Column 1 Input Column 2 86 UV1-b Median Dff. 1,274.50 80 v. UV2-b	2 Sampis Hanii BG UV1-0 N 6 6 6 7 9 1 57 0 1 2 2 2 2 2 2 2 2 2 2 2 3 2 2 3 2 3 2 2 3 2 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 3 2 3 3 2 3 3 2 3	Ho: Median Dift + Ha: Noi equal to 0 Contioence Minemum 1 Mane-Whitin Rank Som? 2 meters	o o o o o o o o o o o o o o	Median 1.275 0 bite bower 90% 690.00	1,695 0 upper 90%	1,700

Den

N

Median Diff. Rank Sum1 22.50 300.5

14

BG UV2-b

Descriptive Statilistics Minemum 1st Quartile Median 3rd Quartile Max 2 13 24 525 0 0 0 0

Menn-Whitney Rank Analysia Hank Sum2 p-value lower 90% upper 90% 105.5 U 000 14.00 660.00

1,700

Analysis Input Column 1 Input Column 2	2 Sample Rank BG	meters his: Median Ditt. = 0 Ha: Not equal is 0 Confidence	09			
			riptive Statla	tics	310 Quartie	Maximum
	N	Manimum	1 SI Cluarfile 2 13			1 70
BG	14		2 13		1.543	
C-c	14		•	16	1,040	1.10
		Mann-Whitne	Rank Anely	ala .		
Median Off.	FLACK SUM1	Rank Surt2	p-value	IUwur 90%	upper 90%	
4.00		185	5 0.433	-95 00	30.00	
input Column 1 input Column 2	BG UV1<	Ha: Not equal to 0 Confidencia	0	1		
			criptive Statis			
	N	Metamum			3rd Quartile	
BG	6	13				
UV1-C	6	18	0 1,496	1,700	1,700	1.70
		Menn-Whitne	Renk Analys			
Median Diff.	Bank Sum1	Flank Sum2	p-value	ower 90%	upper 90%	
-20 00		45.	0 6.394	-1,010.00	250.00	
1000	7					
8G v. UV2-c	Bern					
		Tist Merken Dfl. = 0		6		
Anaryala	2 Sample Rarik	Ho: Medan Dtl = 0				
	2 Sample Rank BG		0.5			

14

Mermum

N

Median Dilt Renk Sum1 14.00 258.0

UV2-C

Descriptive Statistice Maintwith Tat Cuantae Macken 3rd Ouartie Maximum 2 13 24 625 1700 1 7 10 14 1,700

Mann-Whitney Rank Analysia Riana Sum2 p-value kower 90% upper 90% 146.0 0.012 3.00 630.00

		Menn-Whitney F	ank Analysi			
Mechan Det	Flank Sum1	Rank Sum2	p-vaire	NOW NOW O	upper 90%	
6.00	39.0	39.0	0.937	0.00	0 00	
1						
C-4 v. UV2-4						
	Pareme					
Analysis	2 Sample Hank H	o. Median Ott. w 0	0			
input Column 1	C-a H	a: Not equal to 0	C			
	UV2-	entidence	0.9			
		Descri	ptive Statisti			
	N		1at Grantine		3rd Quartile	Maxmun
C.	13	0	0	0	0	
IUV2-in	10	0	0	0	0	
0.42.18	10					
		Menn-Whitney F	lank Anelval			
Median Diff	Rank Sum1	Bank Sum2			upper 90%	
		203.0		0.00		
0 00	203.0	203.0	0.526	0.00	0.00	

Analysis 2 Sample Rams Ho. Median Diff. = 0 Imput Column 1 C-a He: Not excess to 0 Imput Column 2 UV1-a Contribution

5

N

0.9

1at Quentila Median 3rd Quertile 0 0 0 0 0 0 0 0 0

0 0 0

Descriptive St

Minimum

C-a v. UV1-4

C-4

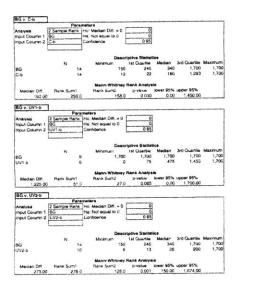
C-6 v. UV1-6 Anelysis 2 Sample Fank Ho: Moxian Dift. = 0 Input Column 1 U-c He: Not equal to 0 Input Column 2 UV1-c Confidence 0 0.95 Descriptive Statistics Minvnum tsiCuartie Median 3rd Quartie Maxi 0 0 10 20 0 0 0 0 Ν 70 5 6 C-b Menn-Whitney Rank Anelysis Rank Sum 1 Hank Sum2 p-value lower 95% upper 95% 46,5 31,5 0,275 0,00 69,00 Median Diff. 9.50 C-b v. UV2-b Descriptive Statistice m 1st Quartie Median 3rd Quartie Maxe 0 0 2 0 0 0 2 N Minimum C-b UV2-b 14 70 Madan Dft, Rank Sum1 Bank Sum2 p-value lower 95% upper 85% 0.00 234.5 171.5 0.074 0.00 2.00

		nelore				
Analysis	2 Sample Rank	Ho: Median Dift = 0	0			
npu: Column 1	UV1-a	He: Not equal to C	0			
input Column 2		Contidence	0.95			
		Descr	plive Statia	ics		
	N	Minimum	1st Quantie	Median	3rd Quarties	Maxmum
IV1-a	6	0	0	0	0	0
JV2-A	10	0	0	0	0	1
		Mano-Whitney				
Median Dil.	Funk Sum1	Hank Sum2				
		150.0	0.445	0.00	0.00	
0.00 UV1-b v. UV2-b	60 0 Para					
UV1-b v. UV2-b Apalysia oput Column 1	Perar 2 Sample Rank UV1-b	saters Ho: Median Oif. = 0 Ha: Not equal to 0 Contidence	0.45			
UV1-b v. UV2-b Analysia input Column 1	Pere 2 Sample Rank UV1-b UV2-b	natiers Ho: Median Det. = 0 Ha: Not equal to 0 Controlence Descr	0 Q 0.95 Notive Statia	lice		
LTV1-b v. UV2-b Anazysia Input Column 1 Input Column 2	Pera 2 Sumple Rank UV1-b UV2-b N	neters Ho: Mecian Dif. = 0 He: Not equal to 0 Contriance Descr Mingrum	0 0.95 1ptive Statia	lice Median	3rd Cuartile	
UV1-b v. UV2-b Analysta Input Column 1 Input Column 2 UV1-b	Pera 2 Sample Rank UV1-b UV2-b N N	neters Ho: Median Off. = 0 Ha: Not equal to 0 Contidence Descr Minimum 0	0 0.95 tptive Statia 1 st Quartile 0	lice Median	U	1
UV1-b v. UV2-b Analysta Input Column 1 Input Column 2 UV1-b	Pera 2 Sumple Rank UV1-b UV2-b N	neters Ho: Mecian Dif. = 0 He: Not equal to 0 Contriance Descr Mingrum	0 0.95 1ptive Statia	lice Median		1
UV1-b v. UV2-b Analysia input Column 1 input Column 2 UV1-b	Pera 2 Sample Rank UV1-b UV2-b N N	neters Ho: Median Off. = 0 He: Not equal to 0 Confidence Descr Minmum 0 0 Menn-Whitney	0 0.95 1st Quartile 0 0 Rank Analy	tice Median O D	0	1
UV1-b v. UV2-b	Pera 2 Sample Rank UV1-b UV2-b N N	natiers Ho: Median Off. = 0 Ha: Not equal to 0 Confidence Descr Minerum 0 0	0 0.95 1st Quartie 0 0 0	lice Median O D	u Dupper 95%	1

	Paramet					
Analysia []	Sample 1 Ho		0			
	Ch Ha	Not equal to U	0			
	UVI-0 Cor	sonecity	0 95			
t,	Pox	venance	TAUE			
		Descriptive Stat	tellos			
	N	Man/	Std Dev.	Std Frr		
	N		1 193 406			
C-b			1,280 205			
0.41-10	•	1,682.30	1,200 200	010.140		
		1-	Test Analy	sis		
Mean Diff.	Std. Err.	1			kower 95%	
75.00	875 125	6.086	6.00	0.934	-2.066.56	2,210 3
C-b v. UV2 b	Parame					
Analysis [2 Sample ! Ho C-b Ha UV2-b Co		0.95 TRUE			
Analysis Input Column 1	2 Sample 1 Ho C-b Ha UV2-6 Co Po	Mean Diff. = 0 Not equal to 0 Indence blod Vanance Descriptive Stat				
Analysis Input Column 1	2 Sample 1 Ho C-b Ha UV2-6 Co Po	Mean Diff. = 0 Not equal to 0 Internar bloc Venance Descriptive Stat Mean	0.95 TRUE			
Analysia (nput Column 1 (nput Column 2 C-b	2 Sample 1 Ho C-b Ha UV2-b Co Po	Mean Diff. = 0 Not equal to 0 Intdence bled Vanance Descriptive Star Mean 722 50	0.95 TRUE Sid. Dev 1.043.083	368 785		
Analyses Input Column 1 Input Column 2	2 Sample 1 Ho C-b Ha UV2-b Co Po	Mean Diff. = 0 Not equal to 0 Intdence bled Vanance Descriptive Star Mean 722 50	0.95 TRUE	368 785		
Analysia (nput Column 1 (nput Column 2 C-b	2 Sample 1 Ho C-b Ha UV2-b Co Po	Mean Diff. = 0 Not equal to 0 Internae oled Vanance Descriptive Stat Mean 722.50 500.00	0.95 TRUE Sta Dev 1.043.083 937.054	368 785 382.551		
Analysia (nput Column 1 (nput Column 2 C-b	2 Sample 1 Ho C-b Ha UV2-b Co Po	Mean Diff. = 0 Not equal to 0 Internae oled Vanance Descriptive Stat Mean 722.50 500.00	0.95 TRUE Sta Dev 1.043.083 937.054 -Test Analy cf	368 785 382.551	lower \$5%	

1-day Mann-Whilney test (Total Coliforms)

BG v C.e						
		moters				
	2 Sample Rank	Hu' Median Ditt. = 0	0			
input Column 1		Ha Not equal to 0	0			
Input Column 2	C-a	Confidence	0.95			
]				
		Desc	riptive Statts	lica		
	N	Minimum	1al Quertile	Median	3rd Quartile	
BG	14	156	245	340		1,700
C-6	12	1	9	23	75	290
		Mann-Whitney	Rank Anety			
Median Off.	Rack Sum1	Back Sum2	D-Visium	Low at 85%	upper 95%	
280.00			0.000	210.00	1,653 00	
280.00	2930	1101				
BG v. UV1-0	1					
		meters		en e		
Analysia	2 Sample Hank	no: Median Orti C	0			
Input Column 1	BG	He Not equal to 0	0	8		
Input Cournn 2	UV1-#	Contidence	0.95			
		1				
			riptive Statis	lics		
	N	Minimum	1st Quartile			
BG		1,70				
UV1-#		i	42	79	140	200
		Mann-Whitney				
Median Diff.	Renk Sum1	Barin Sumi2	p-value	lower 95%	upper 95%	
1.621.50		21.	0.002	1 500.00	1,700.00	in the second
BG v. UV2-4	1					
	Pari	Ho: Median Ditt. = 0		a :		
Analysis						
Input Column 1		Ha Not equal to 0	0.95			
Input Column 2	UV2-A	Contidence	0.95	1		
		1				
		Dee	criptive Statis	tics		
	N	Minimum	1et Quertile	Median	3rd Quartile	Maximum
BG	1	19	0 245	340	1 700	
UV2-0			3 4	0	133	250
		Marun Whitne				
					Loper 95%	
	Rank Sum1	Hank Sum2	p-visue 0.000.0			
2NO UK	2931					



		meters				
Analysis	2 Samply Rank	Ho Modan Diff. = 0	0			
input Column 1	BG	Ha: Not equal to 0	0			
Input Column 2	Ce	Confidence	0 95			
		Desci	iptive Statist	ice		
	N	Minimum	1st Quartie	Median	3rd Quartile	
BG	14	150	245			
C-c	14	130	203	275	1,700	1,700
		Mann-Whitney	Rank Anetys	he .		
Median Ditt	Bank Sum1	Rank Sum2	p-value	iower 95%	upper 95%	
0.0	215.5	190.5	0 569	-60.00	160.00	

 N
 Descriptive Statistics

 N
 Minimum
 127 Garma
 Madein
 3rd Outline
 Maximum

 BG
 6
 1.700
 1.700
 1.700
 1.700
 1.700

 LV1<</td>
 6
 1.700
 1.700
 1.700
 1.700
 1.700

 Mann-Whitey Reak Analysis
 Mann-Whitey Reak Analysis
 Mann-Whitey Reak Analysis
 1.700
 1.700

Mantan Dif Rank Sum1 Rank Sum2 pivaka ineer 95% upper 95% 0.00 39:0 39:0 0.907 0.00 0.00

Analysts	2 Sampie Rank	Ho. Median Ditt = 0	0			
Input Column 1	BĞ	Ha: Not equal to 0	0			
input Column 2	UV2-c	Conference	0.95	1		
		Deed	riptive Statis	tice		
	N	MIDINI	1st Crustine	Madian	3rd Quartile	Maxinum
BG	14	150	245	340		1,700
U12-C	16	16	240	265	320	1,70
		Mano-Whitney	Rank Analys	in.		
Medan Diff	Rank Sum1	Hank Sum2	p-vatue 0 0.059		upper 95%	

				a second second			
		melers					
Ariatysis		Ho: Median Diti.		0			
input Column 1	C-a	Ha- Not equal to	0	0			
Input Column 2	UV1-4	Cunticaence	1	0.95			
				ptive Statist			
	N	Montum		1st OLartie	Mersian	3rd Quartie	
C-0	5	000,630	16	36	47		
UV1-s	6		0	42	79	140	20
				lank Analys			
Median Ditt.	Rank Sum1	Rank Sum2				Upper 95%	
-32 50	35.0			0.589	-140.00	90.00	
C-a v. UV2-a	7		43.0	0.007			
C-e v. UV2-e Parameters Analyse Input Column 1 Input Column 2	2 Sample Rank	Ho, Meckan Diff Ha, Not equal to Confidence	- 0 0	0 0 29.0			
C-e v. UV2-e Parameters Analyse Input Column 1 Input Column 2	2 Sample Rank C-a UV2-a	Ho, Meckan Diff Ha, Not equal to Confidence	- 0 0	0 0 29.0	Modian	3rd Quartile	Maximum
C-e v. UV2-e Parameters Analyse Input Column 1 Input Column 2	2 Sample Rank C-a UV2-a escriptive Statial N 13	Ho, Median Diff Ha, Not equal to Controlence Mos Mosmum	- 0 0	0 0 29.0	Modian 23	3rd Quartile 75	Maximur 29
C-a v. UV2-a Paramutava Analyzia Input Column 1 Input Column 2 D	2 Sample Rank Cra UV2-a escriptive Statial N	Ho, Median Diff Ha, Not equal to Controlence Mos Mosmum	- 0 0	0 0 29.0	Modian	3rd Quartile 75	Maximuri 29
C-a v. UV2-a Perametera Analyze Input Column 1 Input Column 2 D C-a UV2-a	2 Sample Rank C-a UV2-a escriptive Statial N 13	Ho, Meclan Diff He, Not equal to Controlence Nos Meternum	- 0 0	0.95 0.95 1at Guartile 5 4	Modian 23 b	3rd Quartile 75 133	Maximuri 29
C-a v. UV2-a Perametera Analyze Input Column 1 Input Column 2 D C-a UV2-a	2 Sample Rank C-6 UV2-6 escriptive Statial N 13 10	ito, Median Ditt Ha, Not squai to Contidence Nos Minerrum nelysis Rank Sum	0 0 3	0.95 0.95 1at Guartie 6 4 D-Value	Modian 23 6 Iows: 95%	3rd Quartile 75 130 upper 95%	Малтиг 29 25

Parameters						
Analysis	2 Sample Rank	to: Median Dift. = 0	0			
Input Column 1	C-D IF	ta: Not equal to 0	C			
Input Column 2	UV1-0	Confidence	0.95			
De	ecriptive Statistic					
	N	Minimum	1st Quartily			
G-0	6	160	598			
UV1-6	8	0	75	475	1 453	1,700
C-b v. UV2-b Parameters	L					
	2 Samole Bank It	to Median Difl = 0	0			
	C-b .	ta Not equal to 0	0			
innut Column 1						
Input Column 1 Input Column 2	UV2-6	Conkduncu	0.95			
input Column 2	UV2-b	•				
input Column 2 Ov	ascriptive Statustic	a Miomum	1st Quartile		3rd Quertile	
input Column 2 De	N 14	a Minimum 12	1st Guarthe 22	180	1,293	1,700
input Column 2 Ov	ascriptive Statustic	a Miomum	1st Quartile	180		1,700
input Column 2 Ov C-b UV2-b	N 14	a Minimum 12 6 anyaia	Tat Guartile 22 13	180 26	1,293 200	1,700
input Column 2 Ov C-b UV2-b	uscriptive Statietic N 14 10 Whitney Rank An Hans Surn1	a Minimum 12 6 anyaia	1st Guarthe 22	180 26 Iowar 95%	1,293 200 upper 95%	1,700

UV1-a v. UV2-a Parameters Analyse 2 Sample Ramit Ho. Median Diff. = 0 Hour Courrin 1 UV1:s Haut Column 2 UV2:s Contract Courrin 2 UV2:s 0.95 Descriptive Statistics Minimum 1at Guartie Median 3rd Quartie Maximum 0 42 79 140 200 3 4 8 133 250 N 6 10 UV1-a UV2-a Mann-Whitney Rank Anelysia Rank Sum1 Fishk Sum2 p-vasue lower 85% upper 95% 1.46.0 132.5 0.665 -50.00 47.00 Median Diff. 0 00 UV1-6 v. UV2-6 0.95 Descriptive Statietics Mnumum 1st Quartie Median 3rd Quartie Mi 1st Quartie Median 3rd Quartie Mi 75 475 1.453 6 13 26 200 N 1,700 N 6 UV1-0 Mann-Whitney Rank Analysia Median Diff. Rank Sum1 Rank Sum2 p-value lower 95% upper 95% 237.00 83.0 127.0 0.104 -6.00 1,875.00

105

UV1-a v. UV2-a						
		mate/s				
		Ho Mean Dr. v 0	0			
	UV1-a	Ha. Not equal to 0	0			
Input Column 2	UV2-8	Contidence	0.95			
		Pooled Vanance	FALSE			
		Descriptive Stat				
		Mistari		Die Eu		
	N		139 284			
UV1-s	-					
UV2-a	2	850.00	509.117	360.000		
			Test Analy	nie		
Mean Diff	SLO. ETT.	1	CF .		10wer 95%	
-420.00	366 874	-1 145	1.08	0.45?	-5,079 02	4,239 02
UV1-6 v. UV2-6	Peri	malars				
Analysia		Ho: Mean Drfl = 0	0			
		Ha: Not equal to 0	6			
	UV1-6					
Input Column 1 Input Column 2		Contidence	0.95			
		Contidence Publed Variance	0 95 FALSE			
		Puoled Vanance	FALSE			
	UV2-6	Puoled Vanance Descriptive Sta	FALSE	Pid Ca		
Inpus Column 2		Puoled Vanance Descriptive Sta Mean	FALSE Std. Dev			
Jupus Column 2 UV1-b	N A	Puoled Vanance Descriptive Sta Mean 1,292.50	FALSE Std. Dev. 1,280.299	640.148		
Inpus Column 2	UV2-6	Puoled Vanance Descriptive Sta Mean 1,292.50	FALSE Std. Dev	640.148		
Jupus Column 2 UV1-b	N A	Pocied Vanance Descriptive Sis Mean 1,292 50 1,365 00	FALSE Std. Dev. 1,280.299	640.148 *******		
Jupus Column 2 UV1-b	Uv2-6	Pocied Vanance Descriptive Sis Mean 1,292 50 1,365 00	FALSE Std. Dev 1,280,296 1,463,711	640.148 4442755 sle p-value	lower 85%-	

1-day 1-lust (E.coli)

			Ineters			
Non-Wards Non-Wards O B Focuse V strate O B FALSE Non-Wards Station Station Non-Wards Station Station SG 14 45:00 758.400	Analysis	2 Sample :	Ho: Mean Dill # 0	0		
Posed Variance FALSE Descriptive Statistics N Mean Sto Ser Sid Em BG 14 45/00 705 (86 186 876	Input Column 1	BG	ha Not equal to 0	0		
Posed Variance FALSE Descriptive Statistics N Mean Sto Ser Sid Em BG 14 45/00 705 (86 186 876			Contidence	0.9		
N Moan Sto Dev Std Err. 8G 14 491.00 705.968 188.678		A CONTRACTOR OF	Pooled Variance	FALSE		
N Moan Sto Dev Std Err. 8G 14 491.00 705.968 188.678		-				
N Moan Sto Dev Std Err. 8G 14 491.00 705.968 188.678						
BG 14 491.00 705.968 188.678						
85			Descriptive Stat	istics		
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	86		Moan	Sto. Dev.		
		14	Moan 491.00 0.06	Sto. Dev 705.968 0.277	188 678	
	C-#	14 13	Moan 491.00 0.06	Sto. Dev. 705.968	188 678 0 077	
Hean Diff. Std Err. t d p-value kwar 90% upper 90	0.4	14 13	Moan 491.00 0.06	Sto. Dev 705.968 0.277 Tuel Analy	188 678 0 077	

400.92 185.678 2.602 13.00 0.022 156.79 825.05 BG v. UV1-e

Analysis Input Column 1	BG	Ho Mean Diff = 0 Ha: Not equal to 0	0	
Input Column 2	IUV1-a	Contidence	0.95	
	-	Pooied Vanance	FALSE	

		Descriptive Stat	latics		
·	N	Mean		Std. Err.	
BG	6	1,128.33	865.365	271.630	
UV1-6	6	0.00	0.000	0.000	

 International
 Freet Analysis

 Mean DM.
 Std Err
 of p-value lower 95% upper 95%

 1 128 33
 271 630
 4 154
 3.00
 0.025
 263 85
 1,962 78

August Supervision of a second	Paran	neters				
Analysis	2 Sample 1	Ho Mean Dit = 0	0			
Input Coastn 1	IBG II	Ha: Not equal to 0	0			
inuut Column 2		Contidence	0.95			
		Pooled Vanance	FALSE			
	harden and a second					
		Descriptive Stat		Salar		
	N	Descriptive Stat	Std Dev	Sid En		
60	N 14		Std Dev	Sid En 186.678		
60 UV2-#		Mean	Std Dev	186.678		
	14	Mwan 491.00 0.10	Sed Dev 705.968	186.678 0.100		
	14	Mwan 491.00 0.10	Std Dev 705.968 0.315	188.678 0 100	iower \$5%	upper 95

BGV C-b	Paramet	and b				
Analysis	2 Sample 1 Ho.		0	6		
input Column 1		Not equal to 0				
		Trance	0.0			
Input Column 2		Ned Vanance	FALSE			
	Poc	ked Vanance	FALSE			
						-
		Descriptive State	Std Dev	A		
	N	Mean				
BG	14	491.00		185.875		
C-b	14	11 07	23.522	5.287		
			Test Analy			
Mean Ddf.	SIJ. En.	1	di		kwer 90%	
479.83	166 782	2,542	7 02	0 0 39	122 27	837.5
BG v. UV1-b						
	Paramet					
Analysis	2 Samples ! HO.		0			
Input Column 1		Noi equal to 0	0			
Input Column 2		lidence	0.9			
	Pox	Ned Variance	FALSE	() () () () () () () () () ()		
		Descriptive Stati		200200		
	N		Std. Dev			
8G	6	1,128.33		271 630		
UV1-b	8	0.17	0 408	0.167		
	100000000	1-1	est Analy			
Mean Diff	Sta Err	1	đ		kower 90%	
1,128 17	271.630	4.153	3.00	0.025	488 82	1,767.4
BG v. UV2-b	12.5					
	Paramet					
Analysis	2 Sample 1 Ho:		0			
	BG Ha	Not equal to 0	0			
Input Column 2	UV2-6 Cor	lidence	0.9			
	Fox	wed Vanance	FALSE			
		Descriptive Stati				
			Std. Dev			
	N		705.988	168.678		
BG	N 14	491.00				
BG UV2-5		491.00	0.675	0 213		
	14		0.675	0 213		
	14	0.30	0.675	sia		
	14	0.30		sia	IDWAY 90%	upper 90%

wiyaia	2 Sample 1 Ho Mean Diff. = 0 0
ut Column 1	BG Ha Not equal to 0 0
out Column 2	Parameters 0 0 2 Serces Heo Mean DB: = 0 0 0 00 He in the equal to 0 0 0 C-C Contraurce 0.95 0 Pusced Variance 7.455 0
	Count at a Bustistics
	Descriptive Statistics N Meen Stc Dev. Std. En 14 491.00 705.968 188.678 14 590.36 801.177 214.123
G	14 491.00 705.968 188.878
~	14 590.36 601.177 214.123
Mean Diff.	Std. Err. t dt p-value lower \$5% upper \$5%
-99.36	285.391 -0.348 13.91 0.733 -715.91 517.19
G v. UV1-c	
	Paramaters
satysis out Column 1	2 Sample 1 Ho: Mean DM. = 0 0 BG Ha: Not equal to 0 0
put Column 2	UV1-c Confidence 0.95
	Parameters 0 0 (2 Sargest Thro: Mean DH: = 0 0 0 (BG) Tak: Not eposition 0 0 (UV1c Conclamore 0 (Point Variance PALSE
	Descriptive Statistics
0	Descriptive Statistics N Mean Std Dev. Std. Err. 6 1,128.33 665.355 271.630 6 1.398.33 616.195 251.561
/1-c	6 1,398.33 615.195 251.56
19.5% 	
	Frest Analysia Rul Co. di Juvalua Inwar 95% under 95%
Mean Diff. -270.00	Std. Err. t cl p-velue lower 95% upper 95% 370 224 -0 729 3 43 0.519 -1,448.22 908.22
v UV2-C	Personatara
a'ya:4	Persinvetars 0 2 Sampia 1 Ho: Mean DH: = 0 0 5G Ha: Not equal to 0 0 UV2 c Configure 0 0.95 UV2 c Configure 0 0.95
out Column 1	BG Ha: Not equal to D 0
put Golumn 2	UV2.c Confidence 0.95 Pooled Variance FALSE
	Pooled Vanance [PALSE]
	Descriptive Statistics N Mean Std. Dev Std. Err.
G	Descriptivs Statistics N Mean Stat Dev Stat Err. 14 491.00 705 968 138.878 10 283.40 569 295 169.514
/2-c	10 283.40 599.295 189.514
	L'Test Analysis
	d in the lease of the second party
Meen Diff.	Std. Err. 1 df p-value lower 95% upper 95%
-day 1-last (T	Stut: Err of p-value lower 85% upper 85% 2 (27 A22 0,776 5.56 0.473 476.82 885.03 otal Cuilfarma)
I day I-test (T	ofal Guilfarma)
day Heat (T	ofal Guilfarma)
-day I-last (T	ofal Guilfarma)
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-day I-tast (Tr G v. C-a malysis nput Column 1 nput Column 2 	Destination Peramoters RG Hot Repair 10 C-0 Control Vallow Control Vallow Descriptive Statistics N Men 14 9602 13 9602 13
Gay I-tast (To G v. C-s nalysis put Column 1 put Column 2 G -s	Destination Peramoters RG Hot Repair 10 C-0 Control Vallow Control Vallow Descriptive Statistics N Men 14 9602 13 9602 13
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-day Heast (Ti TG v. C-a unayyas nput Column 1 nput Column 2 IG C-a Mean Dift 803 3	Description Control Contro Control Control
-day Heat (Ti 30 v. C-a Vrazysia nput Column 1 nput Column 2 36 C-a Mean Dift 803 3	Description Control Contro Control Control
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I day Haat (T BB v. C-a Analysia Analysia Analysia Analysia BG UVI-a Mean Dift BC VIVI-a Notice Diff Diff Diff Diff Diff Diff Diff Dif	Set Culliamest Parameters Contribution Contribution Descriptive Statistics N Mean Stat Dev. 500 Er. 13 86.02 Er.2038 25.537 13 86.02 Er.2038 25.547 13 86.02 Er.2038 25.547 Descriptive Statistics N Stat Er. 1 201500 3.985 7.31 0.000 3.28.56 1.280.11 Descriptive Statistics 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
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day Heast (17 80 × C + 7 7 80 × C + 7	Parameter Parameter Parameter Parameter Proved Variance Parameter Parameter Proved Variance Parameter Parameter Proved Variance Parameter
day Head (C Gr. C.a. raysa gal Column 2 gal Column 2 G 33.3 GU UVI-a Gar UVI-a	Image: Section of the sectio

	Paramet						Pare
Analysis Input Column 1 Input Column 2	2 Sample 1 Ho. C-a Ha		0			Analysis input Column 1 C input Column 2 U	Sample 1
	Pox	wed Vanance	FALSE				
		Descriptive Sta	listics			1	
	N	Mean		Sut Err		L	N
C-=	5	0.00	0.000	0.000		C-0	6
UV1-R	5	0.00	0.000	0.000		0.110	6
			Test Anely	ais			
Mean Diff.	Std. Err	1	œ	D-VBIUG	lower 95% upper 95%		Std. Er
0.00	0.000	#DIV/0	IVALUE!	VALUE!	VALUE! VALUE!	24.83	13 103
0.00							
						C-b v. UV2-b	
C-e v. UV2-e	Paramete						Para
C-e v. UV2-e Anelysis	2 Sample I Ho	Mean Det = 0	0			Analysia 2	Sample 1
C-e v. UV2-e Anelysis Input Column 1	2 Sample 1 Ho. C-a Ha.	Mean Det = 0 Not equal to 0	0			Analysia unput Column 1	Sample 1
C-e v. UV2-e Anelysis	2 Sample I Ho G-a Ha UV2-a Cor	Mean Ditt. = 0 Not equal to 0 feamore	0 0.95			Analysis Input Column 1	Sample 1
C-e v. UV2-e Anelysis Input Column 1	2 Sample I Ho G-a Ha UV2-a Cor	Mean Det = 0 Not equal to 0	0 0.95 FALSE			Analysia unput Column 1	Sample 1
C-e v. UV2-e Anelysis Input Column 1	2 Sample I Ho G-a Ha UV2-a Cor	Mean Ditt. = 0 Not equal to 0 feamore				Analysia unput Column 1	Sample 1
C-e v. UV2-e Anelysis Input Column 1	2 Sample I Ho. G-a Ha. UV2-a Cor Poc	Mean Det = 0 Not equal to 0 federate sed Variance	FALSE			Analysia unput Column 1	Sample 1 -5 W2-b
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C-e v. UV2-e Analysis Input Column 1 Input Column 2 C-e	2 Sample I Ho. C-a Ha. UV2-a Cor Poc N 13	Mean Dit = 0 Not equal to 0 Hoence Ned Variance Descriptive Stat Miren D 08	FALSE Sta Dev 0.277	0 077		Analysis Input Column 1 Input Column 2 U	Sample 1 -0 V2-b N
C-e v. UV2-e Analysis Input Column 1 Input Column 2 C-e	2 Sample I Ho G-a Ha UV2-a Cor Poc	Mean Ditt = 0 Not equal to 0 Holence Red Variance Descriptive Stat	FALSE Std. Dev			Analysis 2 Input Column 1 Input Column 2	Sample 1
C-e v. UV2-e Analysis Input Column 1 Input Column 2 C-e	2 Sample I Ho. C-a Ha. UV2-a Cor Poc N 13	Mean Det = 0 Not equal to 0 ficence Red Vanence Descriptive Stat Moen 0 06 0 10	FALSE Sta Dev 0.277	0 077 0 100		Analyse Input Column 1 Input Column 2 Uppt Column 2 UV2 b	Sample 1 -0 W2-b N 14 10
C-e v. UV2-e Anelysis Input Column 1	2 Sample I Ho. C-a Ha. UV2-a Cor Poc N 13	Mean Det = 0 Not equal to 0 ficence Red Vanence Descriptive Stat Moen 0 06 0 10	FALSE Sta Dev 0.277 0.315	0 077 0 100	iower 95% upper 95%	Analyse Input Column 1 Input Column 2 Uppt Column 2 UV2 b	Sample 1 -0 V2-b N

		meters				
Analysia	2 Sample 1	Ho: Meian Ditt. = 0	0			
input Column 1	C-b	He Not equal to 0	6			
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		Descriptive Stat	liatics			
	N	Mean	51d Dev			
C-0	6	25.00				
UV1-0	6	0.17	0.408	0.167		
		1	-Test Analy			
Mean Diff.	SId. Er	3	a		10WH 95%	
	13 103		3.00	0.154	-16.87	86.53
	Para	melers		1	- 11	
24.83 C-b v. UV2-b Analysis Input Column 1 Input Column 2	Pere 2 Sample 1 C-b		0 0 95 FALSE			
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C-b v. UV2-b Analysis input Column 1	Pera 2 Sample 1 C-0 UV2-b	nhelers Ho, Mean Diff. « 0 Ha: Not equal to 0 Confidence Pooled Variance Descriptive Sta Mean 11.07	0 95 FALSE	Sic Err 5.287		
C-b v. UV2-b Analystit Input Column 1 Input Column 2 C-D	Pera 2 Sample 1 C-o UV2-b N	nhalers Ho, Mean Diff 0 Ha; Not equal to 0 Confidence Fooled Variance Descriptive Sta Mean 11.07 0.30	0 95 FALSE	Sic En 5 287 0 213		
C-b v. UV2-b Analystit Input Column 1 Input Column 2 C-D	Pera 2 Sample 1 C-o UV2-b N	nhalers Ho, Mean Diff 0 Ha; Not equal to 0 Confidence Fooled Variance Descriptive Sta Mean 11.07 0.30	0 95 FALSE Std. Dev 23 522 0 675	Sic En 5 287 0 213	iower 95%	.700# 95%

	Parame						
Analysia E	2 Sample I Ho	Maran Dell.	.0[0			
Input Column 1	UVI-e Ha	Not equal	100	0			
Input Column 2	UV2-8 CO	nhouncu	- 1	0.95			
I	Pu	und variant	oe L	FALSE			
		Descriptiv		tistics			
	N	Matac		Std. Dev	Std Fr		
UV1-a			0.00	0.000	0 000		
UV2-a	10		0 10	0 316	0 100		
				Teal Anat	eis		
Mean Diff	Std En			dt	p-value	kower 65%	upper 95%
0.00	0.000	#DIV/01		#VALUE!	VALUEI	#VALUE!	#VALUE!
	Parame						
Input Column 1	2 Sample 1 Ho UV1-b Ha UV2-b Cu		100	0.95 FALSE			
Input Column 1	2 Sample 1 Ho UV1-b Ha UV2-b Cu	Mean Dift. Not equal	60 C	FALSE			
Input Column 1	2 Sample 1 Ho UV1-b Ha UV2-b Cu	Mean Ditt. Not equal relidence olect Varian Descriptiv Mean	10 0 08	FALSE Statics			
Input Column 1 Input Column 2	2 Sample 1 Ho UV1-5 Ha UV2-5 Co Po	Mean Ditt. Not equal relidence olect Varian Descriptiv Mean	10 0 08	FALSE Statics	0 167		
Input Column 1 Input Column 2	2 Sample 1 UV1-5 UV2-5 Po N	Mean Ditt. Not equal relidence olect Varian Descriptiv Mean	10 0 08	FALSE Statics	0 167		
Input Column 1 Input Column 2	2 Sample 1 Hd UV1-5 Ha UV2-5 Cc Po N 6 10	Mean Ditt. Not equal relidence olect Varian Descriptiv Mean	10 0 09 0.17 0 30	FALSE Sid Dev 0 406 0.675	0 167 0 213 ysla		
Input Column 1	2 Serripte 1 UVI-0 UVI-0 Ha UV2-0 Po Po N 6 10 Std Err	: Mean Dift. Not equal relidence olect Vanam Descriptiv Mean	10 0 ce [0.17 0.50	FALSE Sid Dev 0 406 0.675	0 167 0 213		upper 95%

Gv.C-b	Ren	malars	-				
malysia		Ho: Mean Dit		0			
nput Column 1		Ha Nol squa		0			
	10-0	Contidence		0.95			
		Pooled Varies	non	FALSE			
	L		- 11 A				
		Descripth					
	N	Mustr		SIG Dev.			
BG .	14		870.00	748.270			
-0	14	: :	548.07	750 651	200.820		
			1.	Test Analy			
Mean Diff.	Std. Em.	t.		d!		lower 95%	
321.93	283.270		1,136	13.64	0.276	-290.04	933.90
G v. UV1-6	7						
01.0110	Par	meters	-				
	12 Sample 1	Ho: Mean Dit	1. = 0	0			
	2 Sample 1 BG	Ha: Not squa		- 0			
sput Column 1	BG		100	0.95			
nput Column 1	BG	Ha: Not squa	1 40 0	0			
sput Column 1	BG	Ha: Not equa Confidence	nce	0.95 FALSE			
nput Column 1 nput Column 2	BG	Ha: Not equa Contidence Pooled Varial Descriptiv Muan	nce ve Stat	0 95 FALSE			
put Column 1 put Column 2 G	8G UV1-6 N	Ha: Not equa Confidence Pooled Varial Descriptiv Muan 1,7	nce ve Stat	0 95 FALSE Std. Dev 0 000	0.000		
nput Column 1 nput Column 2	8G (/v1-6	Ha: Not equa Confidence Pooled Varial Descriptiv Muan 1,7	nce ve Stat	0 95 FALSE	0.000		
nput Column 1 nput Column 2	8G UV1-6 N	Ha: Not equa Confidence Pooled Varial Descriptiv Muan 1,7	nce No 5 tat 700.00 728.33	0 95 FALSE Std. Dev 0 000	0.000 324.514		
put Column 1 put Column 2 G	8G UV1-6 N	Ha: Not equa Confidence Pooled Varial Descriptiv Muan 1,7	nce No 5 tat 700.00 728.33	0 0.95 FALSE Std. Dev 0.000 794.894 Text Analy dl	0.000 324.514 p-value	lower 95%	
put Column 1 put Column 2 G V1-b	N Std Err.	Ha: Not equal Contidence Pooled Vase Descriptiv Moan 1,7 1	nce No 5 tat 700.00 728.33	0 0.95 FALSE Std. Dev 0.000 794.894 Text Analy dl	0.000 324.514		upper 95% 2.004.42
put Column 1 put Column 2 G V1-b Meen Diff. 971.67	N Std Err.	Ha: Not equal Contidence Pooled Vase Descriptiv Moan 1,7 1	2 10 0 nos ve Stat 700.00 728.33	0 0.95 FALSE Std. Dev 0.000 794.894 Text Analy dl	0.000 324.514 p-value		
isput Column 1 Isput Column 2 IG IV1-b Meen Diff. 971.67	N Std Err. 324.514	Ha: Not squa Confidence Pooled Varial Descriptiv Moan 1,7 1	2 10 0 nos ve Stat 700.00 728.33	0 0.95 FALSE Std. Dev 0.000 794.894 Text Analy dl	0.000 324.514 p-value		
nput Column 1 nput Column 2 IG JV1-b Meen Diff. 971 67 IG v. UV2-b	N Std Err. 324.514	Ha: Not equa Confidence Pooled Vana Descriptiv Moan 1,7 1 1 1	2 994	0 095 FALSE Std. Dev 0 000 794.894 Test Analy at 3 00	0.000 324.514 p-value		
nput Column 1 nput Column 2 IG JV1-b Meen Diff. 971 67 IG v. UV2-b vnstyells	N Std Err. 324.514	Ha: Not squa Confidence Pooled Varial Descriptiv Moan 1,7 1	2 954 100 0 700.00 728.33 1- 2 954	0 0.95 FALSE Std. Dev 0.000 794.894 Text Analy dl	0.000 324.514 p-value		
G IV1-b Mean Off. 971.67 G v. UV2-b nalyes put Column 1	BG UV1-b SId Err. 324.514 Part 2 Sample 1 BG	Ha: Not equa Contidence Moded Varial Descriptiv Moan 1,2 1 1 1 1 1,0 1,0 1 1 1 1,0 1,0 1 1 1 1,0 1 1 1,0 1 1,0 1 1,0 1 1,0 1,0	2 954 100 0 700.00 728.33 1- 2 954	0 0.95 FALSE Std. Dev 0.000 794.894 Test Analy dl 3.00	0.000 324.514 p-value		
nput Column 1 nput Column 2 IG JV1-b 971.67 IG v. JV2-b vratyses nput Column 1	N Std Err. 324.514	Ha: Not equal Contidence Protect Varial Descriptiv Moan 1,7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2 954	0 095 FALSE Std. Dev 0 000 794.894 Test Analy ct 3 00	0.000 324.514 p-value		
G IV1-b Mean Off. 971.67 G v. UV2-b nalyes put Column 1	BG UV1-b SId Err. 324.514 Part 2 Sample 1 BG	Ha: Not squa Confidence Proceed Variativ Mean 1,7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2 954	0 95 FALSE FALSE Skil Dev 0 000 794.894 Text Analy at 3 00 0 0.95 FALSE	0.000 324.514 p-value		
IG IG IV1-b Maan Dff. 971.67 IG v. UV2-b matyasa you Column 1	BG UV1-b SId Err. 324.514 Part 2 Sample 1 BG	He: Not equa Confidence Proced Vanai Descriptiv Moan 1,7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2 954	0 95 FALSE FALSE Skil Dev 0 000 794.894 Text Analy at 3 00 0 0.95 FALSE	0.000 324.514 sis p-value 0.056		
	86 UV1-8 N Std Err. 324.514 Part 2 Sample I BG 1/V2-9	he: Not equa Contidence Podeol Vanal Descriptiv Moan 1, 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	L to 0 moe ve Stat 2 994 H = 0 h = 0 moe ve Stat 3 70 00	0 95 FALSE Istice Skil Dev 0 000 794.894 Test Analy dl 3 00 0 0 0.955 FALSE Istice	0.000 324.514 p-value 0.056 Std Err. 199.084		

 Flast Ansitysie

 Mean Diff.
 Sid. Err.
 if
 p-value
 lower 95%

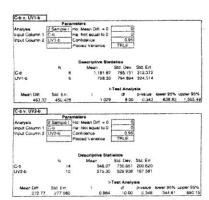
 Sp4 70
 290 915
 2.279
 5.56
 0.072
 .76 00
 1.265.40

and approved to the second	Paramete	**				
Anevala	2 Sample 1 Ho:		01			
Input Courns 1		Not equal to 0	0			
Input Column 2		Idence	0.95			
input content a		ed Verience	FALSE			
	Lange and a second					
	2		10000			
	N	Mean	Etd. Dev	Stat En		
HG.	14		748 270			
				202.538		
Ce	14	636.57	157.829	202.530		
			Test Anal			
Mean Orti.	Std. Err	t	5		iower 95%	
31 43	284 632	C 110	13 9"	0.914	-583 48	646 34
BG v UVI-c	1					
BGV. UVI-C	Paramete	0				
Analysia	2 Sample 1 Ha:		0			
Input Calumn 1		Not equal to 0	0			
Input Column 2		ticeoce	0.95			
ingen Consider s		led Variance	FALSE			
		Descriptive Stat				
	N		Std. Dev			
BG	5	1,700.00		0.000		
UV1-C	6	1,700.00	0.000	0.000		
			Test Anen	ale		
Mean Diff.	Std Err.	- Q - C		D-VEILH	10we- 15%	LODINE 95%
Mean Dim. 0.00		#DIV/0			#VALUE!	
0.00	0.000					
BG v UV2-0	1					
	Paramete			Name and		
Analysis	2 Sampler 1 Hu.		0			
input Column 1		Not equal to G	0			
Input Column 2		TRANCE	0.95			
	Pop	ied Variance	FALSE			
		Descriptive Sta	listics			
	N	Mean	Sid. Dev.	Std. Err		
BG	14	870.00	148 270	199 984		
11/2-6	10	541 00	512.798	193 /84		

1-Test Analysis t dt o-vsice lower 95% upper 95% 1.181 5.33 0.291 -386.63 1,044.83

Mean Dift Sta Err 329.00 278.470

	Parame					
		Mean Drt. = 0	0			
Input Column 1		Not equal to 0	0			
Input Column 2		shidence	0.95			
	Po	oled Variance	FALSE			
		Descriptive Sta	tietics			
	N	Milan	Std. Dev.	Sto En		
C-a			114.098			
UV1-8	6			30.844		
		0.000				
			Test Anal	yais		
Mean Diff.	SM En	3	đ	p-value	jower 95%	upper 96%
-0.77	b9 624	-0 013	2.12	0 991	-257.31	255.7
C-s v. UV2-s						
C-a v. UV2-a Analysis Input Column 1 Input Column 2	C-a Hi UV2-a G	iters y Mean Diff. = 0 a Not equal to 0 policience scied Variance	0 0 0 95 FALSE			
Analysis Input Column 1	2 Sampa I H C a H UV2-a G P	Alean Diff. = 0 a Not equal to 0 onlinence odied Variance Descriptive Sta	C 95 FALSE			a 1999 - 404 00
Analysis Input Column 1 Input Columr, 2	2 Sumpsa I H G-a H UV2-a G P	Alean Diff. = 0 a Not equal to 0 onlicence soled Variance Descriptive Sta Mean	C 95 FALSE			0 <u>15 - 5 - 45</u> 0545
Analysis Input Column 1 Input Column 2 C-a	2 Sumpsu I H C-a HL UV2-a Pr N	/ Mean Diff. = 0 a Not equal to 0 onlicence soled Variance Descriptive Sta Mean 66 62	C 95 FALSE tustics Std. Den 92 038	25 527		0 <u>15 - 2</u> - 466645
Analysis Input Column 1 Input Columr, 2	2 Sumpsa I H G-a H UV2-a G P	/ Mean Diff. = 0 a Not equal to 0 onlicence soled Variance Descriptive Sta Mean 66 62	C 95 FALSE	25 527		
Analysis Input Column 1 Input Column 2 C-a	2 Sumpsu I H C-a HL UV2-a Pr N	y Mean Diff. = 0 a Not equal to 0 prilicence soled Variance Descriptive Sta Mean 65.62 85.00	C 95 FALSE tustics Std. Den 92 038	25 527 30.396		
Analysis Input Column 1 Input Column 2 G-s UV2-n	2 Sumple TH C a H UV2 a G N 13 16 Sis En.	y Mean Diff. = 0 a Not equal to 0 prilicence soled Variance Descriptive Sta Mean 65.62 85.00	C 95 FALSE tustics Std. Dev. 92 038 96.126 -Test Anat df	25.527 30.396 yais p-value		upper 95%



	Pareme	lars				
Analysis	2 Sample 1 He	Mean Din 0	0			
Input Column 1	UV1-a H	: Not equal to 0	ő			
Input Courten 2		volicience	0.95			
	Po	eonanaV bette	FALSE			
		Descriptive Sta	listics			
	N	Mean	Sta Dev.	Std. Err.		
UV1-s	6	91.17	75,552	30.844		
UV2-e	10	69.00	96.128	30,396		
			-Test Anet	vala		
Mean Dill	Std. Err	1		p-value	lower 95%	upper 955
22.17	43.305				#VALUET	#VALUE
UV1-6 v. UV2-6	Parame	bers	IVALUE!	AVALUET	TVALUE:	WAL DE
UV1-b v. UV2-b Analysis input Column 1	Parame 2 Sample 1 Hc UV1-0 Ha UV2-0 Co		0 0.95 FALSE	IVALUET	TVALUE	WALUE
UV1-b v. UV2-b Analysis Input Column 1	Parame 2 Sample 1 UVI-0 UV2-0 CC Po	Ners Mean Diff. k 0 Infidence oled Vanance Descriptive Sta	0 0.95 FALSE		VALUE	WALUE
UV1-b v. UV2-b Analysia input Column 1 Input Column 2	Parame 2 Sample 1 Hc UV1-0 Ha UV2-0 Co	Ners Mean Diff. N D I: Not equal to D nitrience oled Vanance Descriptive Sta Mean	0 0.95 FALSE tistics Sid. Dev.	Sia Err.	VALUE	WALUE
UV1-b v UV2-b Analysta input Column 1 Input Column 2 UV1-b	Parame 2 Sample 1 Ht UV1-0 Cc UV2-0 Cc N N	Mers Mean Diff. n.O. I: Not squal to 0 Infitience Oled Vacance Descriptive Sta Mean 728.33	0 0.95 FALSE tlation Std. Dev 794.894	Sta. Err 324.514	VALUE	WALUE
UV1-6 v UV2-6 Analysis input Column 1 Input Column 2 UV1-6	Parame 2 Sampie 1 2 Vi 1-6 Vi 1-6 VV 2-b CC Po	Mers Mean Diff. n.O. I: Not squal to 0 Infitience Oled Vacance Descriptive Sta Mean 728.33	0 0.95 FALSE tistics Sid. Dev.	Sta. Err 324.514	VALUE	IVALUE
UV1-b v UV2-b Analysia Input Column 1 Input Column 2 UV1-b UV2-b	Parama 2 Sample 1 UV1-0 UV2-0 Po N 6 10	uers - Meuri Ditt. x 0 - Not equal to 0 nthiserce oled Vanance Descriptive Sta Maan 726.33 275.30	0 0.95 FALSE tlation Std. Dev 794.894	Sid. Err. 324.514 167.581 yala		
UV1-b v. UV2-b Analysia input Column 1 Input Column 2	Parame 2 Sample 1 H4 UV1-0 UV2-0 N 6 10 Srd Err.	Mers Mers Mers Dit. s 0 interce olect Vanance Descriptive Sta Maan 726.33 275.30	0 0.95 FALSE tistics Std. Dev. 794.894 S29.935	Sid. Err. 324.514 167.581 p-value	kower (65%	

2-day Mann Whitney test (E.coll)

Maximur 1.75
3 1.75))
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Maximum
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Mesan Diff Furk Sum1 Herk Sum2 prank Analysis 122.50 222.0 78.0 11.000 75.00 870.00

	Para	melera					
Analysis	2 Satisury Haria	Ho Mudian Dif: e	0 [0			
Insul Column 1	UVI-a	His Not equal to 0	1	0			
input Column 2	UV2 e	Contidence	[0,95			
		0		ptive Statis			
	N	Manimum		1al Guidrilled	Median	3rd Quartile	Maximum
UV1-#	6		0	0	0	0	(
UV2-a	ε		0	0	0	0	4
		Mann-White	wy F	lank Analys			
Median Diff.	Rank Sum1	Rank Sum2		p-value	kower 95%	upper 95%	
0.00	57.0	11	4.0	#VALUE!	0.00	0.00	
UV1-b v. UV2-b	Para	melars					
	Pare 2 Sampe Renk UV1-0	meters Ho: Mecan Diff. = Ha: Not equal to 0 Confidence		0 0 0.95			
Anelyais Input Column 1	Para 2 Sampe Reta UV1-0 UV2-0	Ho: Mecaan Diff. = His: Noi equal to 0 Confidence	ecri	plive Staties			
Analysia Input Column 1 Input Column 2	Para 2 Sampe Kank UV1-b UV2-b N	Hor Mecken Diff. = He. Noi equal to 0 Confidence Mormum	ecri	plive Staties		3rd Quartie	Maximum
Analysia Input Column 1 Input Column 2 UV1-b	Para 2 Sampie Hank UV1-0 UV2-0 N	Hor Meckan Diff, = His: Not equal to 0 Confidence Mormum	ecri	plive Staties		0	Maximum
Analysia Input Column 1 Input Column 2	Para 2 Sampe Kank UV1-b UV2-b N	Hor Meckan Diff, = His: Not equal to 0 Confidence Mormum	ecri	plive Staties			Maximum C
Analysas Input Column 1 Input Column 2 UV1-b UV2-b	Para 2 Sampao Hank UV1-6 UV2-6 N N 6 8	Hor Mackan Diff, = His, Noi equal to D Contribunce Marmum Mann-White	G O O	ptive Statist 151 Guertie 0 0 Rank Anatys	Median G C	0	Maximum C C
Analysia Input Column 1 Input Column 2 UV1-b	Para 2 Sampa Ranà UV1-0 UV2-0 N 8 Bank Sum1	Ho: Meckan Diff, = Hit: Nol equal to D Contridence Microsoft Mann-White Hans Sume	G G O May F	ptive Statist 151 Guertie 0 0 Rank Anatys	Median G C	0 0 upper 95%	o c

		Ho Median Dri		0			
Analysis							
input Column 1		Ha. Not equal to I		0			
Input Column 2	C-c	Contidence	10	09			
		1	- 17				
		i Berne and an anna					
	Contractor of the second second	D	escri	ptive Statle	lice		
	N	Maximum		1st Quartile	Median	Srd Quertilo	Maximum
BG	13	2	10	70	123	1.073	1.75
C-c	12	2	5	30			1.75
				30		~~~	
		Mano-Whit	nev F	Renk Anely	la		
Median Diff.	Renk Sum1	Rana Sum2				upper 90%	
50.00			35.5	0.418			
	104 :		33.5	0.4.0	-00.00	613.00	
BG v. UV1-c	1						
		meters					
Analysis	2 Sample Rank	Ho: Medan Diff	• 0 [0			
Input Column 1	BG	Ha Not equal to (0			
Inout Column 2		Confidence	1	0.9			
and the second s							
		-					
				pove Statis			
100	N	Manamam		1st Quartie		3rd Qualifie	
BG	6		130	735		1,733	1,750
UVI-C	6		90	253	395	583	700
		MagnaWhite	any B	ant Analys	Je		
Martine Diff	Bank Sum1	Mann-White	ney R			LEGAL DON	
Median Diff.	Rank Sum1	Rank Sum2		p-Value	lowe: 90%	upper 90%	
Median Dift. 860.00		Rank Sum2	Ney A		lowe: 90%	upper 90% 1,430.00	
860.00		Rank Sum2		p-Value	lowe: 90%		
	51.0] Para	Rank Sum2	27.0	p-Value	lowe: 90%		
860.00 BG v. UV2-c	51.0 Pere	Rank Sum2 meters Ho: Metaen Diff.	0 [p-Value	lowe: 90%		
860.00	51.0 Pere	Rank Sum2 meters Ho: Metaen Diff.	0 [p-value D.065	lowe: 90%		
BB0.00 BG v. UV2-c Analysis Input Column 1	51.0 Para 2 Sample Rana BG	Rank Sum2 meters Ho: Median Diff Itia: Not equal to 0	0 [p-value 0.065	lowe: 90%		
BB0.00 BG v. UV2-c Analysis Input Column 1	51.0 Para 2 Sample Rana BG	Rank Sum2 meters Ho: Metaen Diff.	0 [p-value 0.065	lowe: 90%		
860.00 BG v. UV2-c Analysis	51.0 Para 2 Sample Rana BG	Rank Sum2 meters Ho: Median Diff Itia: Not equal to 0 Confidence	0	p-velue D 065 0 0 0 0.9	10441 90% 90.00		
BB0.00 BG v. UV2-c Analysis Input Column 1	51.0 Para 2 Sample Rana BG UV2-c	Rank Sum2 meters Ho: Median Diff - If sa: Hot equal to 0 Confidence D	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	10we1 90% 90.00	1,430.00	
BB0.00 BG v. UV2-c Analysis Input Column 1 Input Column 2	51.0 Para 2 Sample Rank BG UV2-c N	Rank Sum2 meters ho: Median Diff. tsa: Hot equal to C Confidence Minimum	0 -	D-Velue D-065 0 0 0 0 0 0 0 9 0 9 0 9 0 9 0 9 0 9 0	iower 90%- 90.00	1,430,00 3rd Quartie	
BBC 00 BG v. UV2-c Analysis Input Column 1 Input Column 2 BG	51.0 Para 2 Sample Flank BG UV2-c N N	Rank Sum2 meters Ho: Median Diff. Tra: Hot equal to (Cunticisnos Cunticisnos Di Minimum	0	p-velue 0 065 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	lower 90% 90.00 lics Median 123	1,430.00 3rd Quartile 1,073	1,750
BBC 00 BG v. UV2-c Analysis Input Column 1 Input Column 2 BG	51.0 Para 2 Sample Rank BG UV2-c N	Rank Sum2 meters Ho: Median Diff. Tra: Hot equal to (Cunticisnos Cunticisnos Di Minimum	0 -	D-Velue D-065 0 0 0 0 0 0 0 9 0 9 0 9 0 9 0 9 0 9 0	iower 90%- 90.00	1,430,00 3rd Quartie	
BBC 00 BG v. UV2-c Analysis Input Column 1 Input Column 2 BG	51.0 Para 2 Sample Flank BG UV2-c N N	Rank Som2 meters Ho: Median Diff - tra: Not equal to (Confidence Di Minimum	10 20	p-velue D 065 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	lower 90% 90.00 lics Median 123 58	1,430.00 3rd Quartile 1,073	1,750
BB0.00 BG v. UV2-c Analysis Input Column 1	51.0 Para 2 Sample Flank BG UV2-c N N	Rank Sum2 meters Ho: Median Diff. Tra: Hot equal to (Cunticisnos Cunticisnos Di Minimum	10 20	D-Value D 065 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	iower 90% 90.00 lice Median 123 58	1,430.00 3rd Quartile 1,073	1,750

		meters.					
Analysis	2 Sample Rank	Ho Median Diff	0	0			
input Column 1	C·a	Ha: Not equal to U		0			
input Column 2	UV1-a	Confidence	1	3.9			
		De	ecrip	dive Statisti	ca		
	N	Minimute	1	at Guartie	Median	3rd Quartile	Maxenum
C-a	6		0	0	0	0	6
UV1-a	6		0	0	0	0	0
		Mann-White	ey R.	ank Analysi			
Median Diff	Rank Sum1	Hank Sum2		p-value	wer son.	upper 90%	
0.00	39.0	35	0.6	0.937	0.00	0.00	
C-a v. UV2-a							
	Para	melers					
Analysis	2 Sample Rank	Ho: Median Dill .	or	0			
input Column 1	C-a	He Not equal to 0		0			
Input Column 2	UV2-a	Conticence	C	0.9			
	L						
				tive Statisti			
	N	Manmum	1	at Quartile	Media/i	3rd Quartele	Maximum
G-8	12		0	0	0	0	0
UV2-8	8						

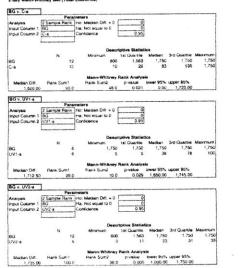
	G-8	12	0	0	0	0	6
	UV2-8	8	0	0	0	0	
			Menn-Whiloey	Rank Analys	sta		
- 1	Median Diff.	Rank Sum1	Rank Sum2	p-value	Kmm# 90%	upper 90%	
	0.00	150.0	150.0	#VALUE!	0.00	0.00	Service-se

Ingut Gourn 2 UT1-0 Commerce C-0 N Merce U/1 0 6 Merce 0.00 39/0 Sec. C-1 V. UV2-b Perameters Mana 11-b C-2 V. UV2-b Perameters Merce Mingt Courn 1 2 General Networks Mingt Courn 1 2 Commerce N Merce N	Descripti	p-value k	Modian 0 0		6
Ingut Gourn 2 UT1-0 Commerce C-0 N Merce U/1 0 6 Merce 0.00 39/0 Sec. C-1 V. UV2-b Perameters Mana 11-b C-2 V. UV2-b Perameters Merce Mingt Courn 1 2 General Networks Mingt Courn 1 2 Commerce N Merce N	Deacript num 1at 0 G Whitney Ran Sum2 1	Ne Statistic Coartile 0 0 na Analysis p-value k	Median 0 0	0 0 upper 95%	6
C-6 / Merris U/10 / E MacSar/Def, Reins Sum1 0/00 / Birl 0 C-5 v. UV24 C-5 v. UV24 Arabys Inguit Column 1 (<u>C-5 v. UV24</u> 2 <u>Deremeter</u> Res Vor e Inguit Column 1 (<u>C-5 v. UV24</u> Commence Control (<u>C-5 v. UV24</u>) Control (<u>C-5 </u>	Deacripti num 1 at 0 6 Whitney Ran Sum2 5	Ne Statistic Coartile 0 0 na Analysis p-value k	Median 0 0	0 0 upper 95%	6
Col E UV1 0 6 Allace Det, 39/0 Colo 39/0 Colo 20/0 Parameters Analyse Impol Column 1/2 Colo Impol Column 2 Commence Colo Commence Maction 2 Commence N Mere	Num 1 at 0 G Whitney Ran Sum2 5	Countile 0 0 na. Analysis p-value k	Median 0 0	0 0 upper 95%	6
Col E UV1 0 6 Allace Det, 39/0 Colo 39/0 Colo 20/0 Parameters Analyse Impol Column 1/2 Colo Impol Column 2 Commence Colo Commence Maction 2 Commence N Mere	0 G Whitney Ran Gum2 p	0 0 hk Anelysis p-value k	0 0 1 0www.95%	0 0 upper 95%	6
UU16 E Machan Dri, Rank Sumt Rack 200 Color UV26 Color UV26 Color UV26 Parameters Machan Sumt Sumt Sumt Parameters Machan Sumt Sumt Sumt Sumt Color II 2 UV26 Color Sumt Sumt Sumt Sumt Sumt Color II 2 UV26 N Meret	Whitney Ran Jum2 1	p-value k	uwer 95%		0
Ausber Def, Pank Sum Facx 0.00 Bit 0 Crb k. UV24 Aralyse Impol Column 12 Discussion Column 2 Discussion Colu	Whitney Ran Jum2 1	p-value k	uwer 95%		c
Madan Diri, Rein Sunt, Ran, 39.0. 39.0. Crb v. UV28 Analyse Zastramiters Ingut Column 1 C-0. His: Not eq Ingut Column 2 UV21 His: Not eq Conducts 2 UV21 Not Market	ium2 I	p-value k	uwer 95%		
0.00 39.0 C-b v. UV2-b Parameters Analyse [2.5urps Kess, 1-b. Mess Imput Column 2 [UV2-10] Column 2 [UV2-10] No Mess					
C-b y. UV2-b Parameters Analyse 2 <u>Strongen</u> News 100 All Column 1 Imput Column 2 UV2/c N News	39.0	0.937	0.00	0.00	
Parameters Analyse 2 Surrore Rena, Ho Media Input Column 2 UV2:b Conndexion					
Input Column 1 C-8 Ha: Not eq Input Column 2 UV2-b Connderson					
Input Column 2 UV2-b Connder on		0			
N Mrat		0			
		0.95			
	Descriptio	ve Statistic			
				3rd Quartine	Meximum
	0	0	0	ú	0
UV2-b 6		G	D	0	٥
Median Diff. Rans Sum1 Rank	0				

Median Diff, Rank Sum1, Plank Sum2, p-value, kowat 65% upper 95% 6.00, 150.0, 150.0, VALUER, 0.00, 0.00

BG v. C-c Parameters

2-day Mann-Whitney test (Total Coliforms)



	Para	meters				
Acabats		Into: Median Diff. = 0	0			
input Column 1		Ha' Not equal to 0	0			
Insut Column 2		Contribunce	0.95			2
REPUT COUNTY &	0.0	Lonnoence	0.95			
		1				
		Descri	ptive Statis	lica		1
	N	Moimum	1st Quettino	Macian	3rd Quarters	Maxuthat
BG	12	600	1,583	1,750	1,750	1,750
C-b	12	0	9	20	53	1,750
						00223
		Mann-Whitney F		KOWWY \$5%	LINE LINE	
Meckan Diff.	Rank Sum1		p-value 0.003		1 750 00	
1,700.00	95.0	410	0.003	000.00	1,750.00	
AG v UVI-b	1					
	Pere	meters				
Analysis		Ho: Mudan Dit = 0	0			
Input Column 1	BG	Ha Not equal to 0	0			
neut Courn 2	UV1-D	Contidence	0.95			
			ptive Statle			
	N		plive Statler	Median		
3G	N	Minimum 1,750	1el Quartile 1,750	Median 1,750	1,750	1,750
	N 6	Minimum 1,750	Isl Quartie	Median 1,750		
	6	Minimum 1,750 105	1el Quartie 1,750 481	Median 1,750 606	1,750	1,750
BG UV1-8	6	Minimum 1,750 105 Menn-Whitney F	Tel Quartie 1,750 481 Renk Anslys	Median 1.750 508	1,750 704	1,750
Median Diff.	6 6 Rene Sum1	Minimum 1,760 105 Menn-Wrbitney F Rank Sumiz	Tel Quartie 1,750 481 Bank Analys p-value	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
J¥1-0	6 6 Rene Sum1	Minimum 1,760 105 Menn-Wrbitney F Rank Sumiz	Tel Quartie 1,750 481 Renk Anslys	Median 1.750 508	1,750 704 upper 95%	1,750 910
UV1-8 Median Diff. 1,142.50	6 6 Rene Sum1	Minimum 1,760 105 Menn-Wrbitney F Rank Sumiz	Tel Quartie 1,750 481 Bank Analys p-value	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
Weaten Diff.	6 6 9 8anii Sumi 28.0 1 9 9anii	Minimum 1,760 105 Menn-Whitney F Hank Suni2 10.0	1el Quartie 1,750 481 Renk Ansiye p-value 0.029	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
Median Diff. 1,142.60 BG v. UV2-5 Analysis	6 6 8	Minimum 1,760 105 Mann-Whitney F Rank Suni2 10.0 Median Ditt. < 0	1el Quartie 1,750 481 Denk Ansiye D-value 0.029	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
Median Diff. 1,142.60 BG v. UV2-b Anarysia	6 6 8	Minimum 1,750 105 Menn-VrNtsrey F Rank Sunix 10.0 Inveters Ho Median Ditt. + 6 Ha: Not equal to 0	1el Quartie 1,750 481 Denk Ansiye D-value 0.029 0 0	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
Median Diff. 1,142.60 BG v. UV2-b Anarysia nput Column 1	6 6 Rane Sum1 26.0 Pera [2 Semple Fank BG	Minimum 1,760 105 Mann-Whitney F Rank Suni2 10.0 Median Ditt. < 0	1el Quartie 1,750 481 Denk Ansiye D-value 0.029	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
Median Diff. 1,142.60 BG v. UV2-b Analysis input Column 1	6 6 Rane Sum1 26.0 Pera [2 Semple Fank BG	Minimum 1,750 105 Menn-VrNtsrey F Rank Sunix 10.0 Inveters Ho Median Ditt. + 6 Ha: Not equal to 0	1el Quartie 1,750 481 Denk Ansiye D-value 0.029 0 0	Median 1.750 608 kas	1,750 704 upper 95%	1,750 910
Median Diff. 1,142.60 BG v. UV2-b Analysis input Column 1	6 6 Rane Sum1 26.0 Pera [2 Semple Fank BG	Minimum 1,760 105 Mann-MrNsway F Rank Suniz 10.0 Median Diff = 0 Child Repair to 0 Conferme	1el Quartie 1,750 481 D-velue 0 029 0 0 95	Median 1.750 506 kower 95% 840.00	1,750 704 upper 95%	1,750 910
Median Diff. 1,142.60 BG v. UV2-b Analysis input Column 1	6 Rank Sum1 25.0 25.0 25.0 25.0 25.0 25.0 25.0 25.0	Minimum 1.750 105 Mann-Mthiswey F Hank Swariz 10.0 Inseters Pro Meclan Ditl. = 0 Confidence Confidence Descri	1el Quartie 1,750 481 benk Anelye p-velue 0.029 0 0 0 0 0 0 0 0 95	Meduan 1.750 808 kower 95% 840.00	1,750 704 upper 95% 1,645.00	1,750 910
Median Diff. 1,142.60 BG v. UV2-b Anaryaas input Column 1 hiput Column 2	6 Rank Sum1 25.0 Pere Sample Rank BG UV2-0 N	Minimum 1,750 105 Nann-Whitwey F Hank Sunia 10.0 Noters Ho, Mackan Ditt = 0 Confernce Confernce Minimum	1al Quartie 1.750 481 2anti Anstys p-value 0.029 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0	Median 1.750 909 kower 95% 840.00 tica Median	1,750 704 upper 95% 1,645.00 3rd Quantile	1,750 910 Maximum
Median Diff. 1,142,50 BG v. UV2-b Anarysis Input Column 1 Input Column 2 BG	6 Plane Sum1 25.0 Pera 25.0 Pera BG UV2-0 N 12	Minimum 1,750 105 Mann-Whitwey F Hank Swinz 10.0 meters Into Median DRI = 0 [Confidence Descri Minimum 650	1at Quartile 1,750 481 Bank Ansilye p-value 0 0 0 0 0 95 0 95 1at Quartile 1,583	Median 1.750 808 iower 95% 840.00 	1,750 704 upper 95% 1,645.00 3rd Quartile 1,750	1,750 910 Maxmun 1,750
Medien Diff. <u>1,142,50</u> BG v. UV2-b Ananyaks input Column 1 input Column 2 BG	6 Rank Sum1 25.0 Pere Sample Rank BG UV2-0 N	Minimum 1,750 105 Mann-Whitwey F Hank Swinz 10.0 meters Into Median DRI = 0 [Confidence Descri Minimum 650	1al Quartie 1.750 481 2anti Anstys p-value 0.029 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0	Median 1.750 808 iower 95% 840.00 	1,750 704 upper 95% 1,645.00 3rd Quartile 1,750	1,750 910 Maxmun 1,750
Medien Diff. <u>1,142,50</u> BG v. UV2-b Ananyaks input Column 1 input Column 2 BG	6 Plane Sum1 25.0 Pera 25.0 Pera BG UV2-0 N 12	Minimum 1,750 105 Mann-Whitwey F Hank Swinz 10.0 meters Into Median DRI = 0 [Confidence Descri Minimum 650	1et Quartile 1.750 481 D-value D-value 0.029 0.095 0.955 ptive Statte 1.563 0 0 0 0 0 0 0 0 0 0 0 0 0	Median 1.750 808 iower 95% 840.00 ica Modian 1.750 23	1,750 704 upper 95% 1,645.00 3rd Quartile 1,750	1,750 910 Maxmun 1,750
Median Diff. 1,142.60 BG v. UV2-b Analysis input Column 1	6 Plane Sum1 25.0 Pera 25.0 Pera BG UV2-0 N 12	Menimum 1,750 105 Mean-Whiteey F Rank Sumi 10.0 Desers Jac Mesoan Det = 0 [Confloence Confloence Minimum 600 0	1et Quartile 1.750 481 D-value D-value 0.029 0.095 0.955 ptive Statte 1.563 0 0 0 0 0 0 0 0 0 0 0 0 0	Median 1.750 808 iower 95% 840.00 tica Median 1.750 23 tika Dower 95%	1,750 704 upper 95% 1,645.00 3rd Quartile 1,750	1,750 916 Махятчит 1,750 85

	Parame	date -	1 Inc. Page. 1 191 192 201 201			
1033330	2 Sample Flats H		0			
			0			
Input Column 1		B. Not squal to C	0.95			
Input Column 2	C-c 0	onficence	0.95			
		120-03				
		Matrum	ptive Statist	JCe	3rd Quartile	Maximum
	N	Mutimum	1.563	1.750		1.75
BG	12			1,750		1.75
C-4	14	600	1,540	1,750	1,230	1,75
		Mann-Whitney				
Median Drff	Rank Sum1	Rana Sum2	p-value		upper 95%	
0.00	71.0	65.0	0 798	0.00	30.00	
			and the second division of the second			
BG v. UV1-c	1					
	Parama					
Analyse	2 Sample Rank H		0			
		a: Not equal to 0	0			
input Column 2	UV1-c G	anhaence [0.95			
			iptive Statis			
	н	Minimum	1st Quarthe		3rd Ouartrie	
BG	6	1,750	1,750	1.750		
UVI-C	6	1,750	1,750	1,750	1.750	1./5
		1221010-02221021001				
		Macm-Whitney				
Modan Diff.	Flank Sum1	Bank Sum2	p-value	kower 95%	upper 95%	
Modian Diff.				kower 95% 5 00		
0.00		Rank Suma	p-value	kower 95%		
	16.0	Rank Sumu 18.0	p-value	kower 95%		
0.00 BG v. UV2-c	16.0] Parama	Rank Sumi 18.0	p-value 0.886	kower 95%		
0.00 BG v. UV2-c Analysis	16.0 Parama 2 Sample Rank Jh	Rank Sum: 18.0 stem o' Modarn Ditt. + 0 [p-value 0.886	kower 95%		
6.00 BG v. UV2-c Analysis Input Solumo 1	16.0 Parame 2 Sample Rank h BG	Rank Sumi 18.0 sters of Mecsan Diff. = 0 s; Not equel to 0	p-value 0.836 0.000	kower 95%		
6.00 BG v. UV2-c Analysis Input Solumo 1	16.0 Parame 2 Sample Rank In BG	Rank Sum: 18.0 stem o' Modarn Ditt. + 0 [p-value 0.886	kower 95%		
6.00 BG v. UV2-c Analysis Input Solumo 1	16.0 Parame 2 Sample Rank h BG	Rank Sumi 18.0 sters of Mecsan Diff. = 0 s; Not equel to 0	p-value 0.836 0.000	kower 95%		
6.00 BG v. UV2-c Analysis Input Solumo 1	16.0 Parame 2 Sample Rank h BG	Rank Sumi 18.0 aters of Madaun Ditt. = 0 a: Not squar to 0 ontidemore	0.886 0.886 0.95 0.95	10wer 95% 5 00	0.00	
6.00 BG v. UV2-c Analysis Input Solumo 1	16.0 Parame 2 Sample Rank h BG	Rank Sumi: 18.0 stern or Maquan Ditt. = 0 (a: Not squal to 0 ontoance Desor Micernum	0.886 0.886 0.05 0.95 tpt/ve Statia 1st Quarter	lower 95% 5 00 tice Median	0.00 3rd Quertier	Maxmur
6.00 BG v. UV2-c Analysis Input Solumo 1	16.0 Param 2 Sample Rank H BG UV2-C C	Rank Sumi 18.0 viers of Madaun Ditt. = 0 viers in Not squar to 0 onthoence Descri Micemum 600	0.696 0.696 0.05 0.95 tptive Statiat 1st Quartier 1.503	lower 95% 5 00 tice Median 1,750	3rd Quartile 1,750	Maxmun 1,75
0.00 BC v. UV2-c Analysis Input Column 1 Input Column 2	16.0 Parame (2.5ample Rank H BG UV2: C	Rank Sumi: 18.0 stern or Maquan Ditt. = 0 (a: Not squal to 0 ontoance Desor Micernum	0.886 0.886 0.05 0.95 tpt/ve Statia 1st Quarter	lower 95% 5 00 tice Median	3rd Quartile 1,750	Maxmun 1,75
0.00 BG v. UV2-c Analysis Input Column 1 Input Column 2 BIG	16.0 Parama 2 Samole Hank In Bô UV2-c 0 N 12	Rank Sumi: 18.0 sten or Medaun Ditt. = 0 10.0 Keduet to 6 ontoence Descr Minemum 600 0	0.896 0.9550 0.9550 0.9550 0.9550000000000	lower 95% 5 00 tics Median 1,750 700	3rd Quartile 1,750	Maxmun 1,75
0.00 BG v. UV2-c Analysis Input Column 1 Input Column 2 BIG	16.0 Parama 2 Samole Hank In Bô UV2-c 0 N 12	Rank Sumi 18.0 viers of Madaun Ditt. = 0 viers in Not squar to 0 onthoence Descri Micemum 600	0.896 0.9550 0.9550 0.9550 0.9550000000000	lower 95% 5 00 tics Median 1,750 700	3rd Quartile 1,750	Maxmun 1,75

C-+ v. UV1-+

C-a v. UV1-a							
		melere					
	2 Sample Ruik			0			
input Column 1	C-#	Ha: Not equal to	0	0			
Input Column 2	UV1-B	Considence	1	0 95			
		1					
				ptive Statist		to a second second	and a second
	N	Minemum				3rd Quartine	
C-8	6		30	98			
UV1-a	6		5	5	38	78	100
		Menn-Wh	Iney F	ank Analys			
Memory Dit.	Funk Sum1	Rack Sum	2	p-value	Awar 95%	upper 95%	
	24.0		12.0	0 114	-70.00	1,745.00	
C-s v. UV2-s Paramoters	2 Sample Rank C-s		- 6 [0114	-70.90	1,745.00	
C-a v. UV2-a Parameters Analysis Input Column 1 Input Column 2	2 Sample Rank C-s	Ho: Median Ditt Ha: Not equal to Contridence	- 6 [0		1,745 00	Maximum
C-a v. UV2-a Parameters Analysis Input Column 1 Input Column 2	2 Sample Aans C-a UV2-a escriptive Statial	Ho: Median Ditt Ha: Not aqual to Contribution Sice Minimum	- 6 [0) 0 0 95 1st Guerne 29	Median 83	3rd Quartile 535	1,750
E-a v. UV2-a Parameters Analysis Input Column 1 Input Column 2 D	2 Sample Aann Cru LIV2-a escriptive Statiat N	Ho. Median Ditt Her Not equal to Contriducion Sice Minimum		0 0 95 1st Guerten	Median 83	3rd Quartile 535	1,750
C-s v. UV2-s Parameters Analysis Input Column 1 Input Column 2 D C-s UV2-s	2 Sample Rank C-a UV2-a UV2-a N N 12 0 Whitney Rank A	Ho: Median Ditt Ha: Not aqual to Contribution dice Minimum	10 10 0	0 0 0 95 1st Guerne 28 11	Median 83 23	3rd Quartile 535 31	1,750
C-s v. UV2-s Parameters Analysis Input Column 1 Input Column 2 D C-s UV2-s	2 Sample Rank C-a UV2-a UV2-a N N 12 0 Whitney Rank A	Ho: Median Ditt Ha: Not squal to Contidence Sice Minimum	10 10 0	0 0 0 95 1st Guerne 28 11	Median 83 23 kower 95%	3rd Quartile 535 31	1,750

C-B v: 0/1-5 Stander Ren. No Modur. Dr. + 0 0 Provid Column 7: Stander Ren. No Modur. Dr. + 0 0 Provid Column 7: Column 7: Description Statistics 0 Description Statistics Minimum 18 Outsite Middan 3rd Duartie UV1-0 5 VO 25 473 1.720 W1-0 6 VO 451 60 C 704 910 Manny Whiting Reak Analysis Middan Diff. 20 0.342 410.00 1,945.00 Column 1: Column 2: VI-0 20 0.342 910 910 Madan Diff. Fact Sum2 postal 0.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,955.00 0.02 3.01 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,945.00 1,

		meters					
Arialysis	2 Semple Rank	Ho: Median Diff.	-0	C			
Input Column 1	UV1-a	Ha: Not equal to	0	0			
Input Column 2	UV2-a	Conticiance	100	0.95			
]					
		t	Descr	iptive Statial	ics.		
	N	Minimum		1st Guartile	Median	3rd Quartile	
UV1-#	6	0.00000000	5	5	38	78	100
UV2-0			30	30	30	30	30
				Rank Analys			
	Bank Sum!	Hank Sum2		U-VALUE	10war 95%	upper 95%	
Median DWI.							
22.50 JV1-6 v. UV2-6	24.0 Para		120	0.114	-25.00	166.00	
	24.0 Pera 2 Sample Blank	invetors.	-0		-25.00	169.00	
22.50 UV1-b v. UV2-b Analysis Input Goumn 1	24.0 Pera 2 Sample Rank UV1-b	inuters Ho: Median Diff Ha: Not squal to Contidence	•0	0.114	ka		
22.50 UV1-b v. UV2-b Analysis Input Column 1	24.0 Pera 2 Sample Rank UV1-b	inuters Ho: Median Diff Ha: Not squal to Contidence	120 • 0 0	0.114 0 0 0 95	ika Median	3rd Quertier	
22.50 UV1-b v. UV2-b Analysis Input Coumn 1 Input Coumn 2	24.0 Pere 2 Sample Flank UV1-b UV2-b) Invatiens Ho: Medean Diff. Ha: Not squal to Contidence Mesthern	120 • 0 0 Descr	0.114 0 0 0 0 95 1 1 1 0 95	ika Median 905	3rd Quartia 704	910
22.5c UV1-b v. UV2-b Analysis Input Goumn 1 Input Coumn 2 UV1-b	24.0 Para 2 Sample Rank UV1-b UV2-b N) Invatiens Ho: Medean Diff. Ha: Not squal to Contidence Mesthern	120 • 0 0	0.114 0 0 0 95	ika Median	3rd Quertier	
22.50 UV1-b v. UV2-b Analysis Input Goumn 1	24.0 Para 2 Sample Rank UV1-b UV2-b N) Insters Pro: Median Diff Ha: Not equal to Contidence Mesmon S Mesmon	- 0 0 0 0 0 0 0 0 0 0 0	0.114 0 0 0 95 1st Quarke 461 0 Rank Analys	lica Median GOU U	3rd Quertie 704 U	910
22.5c UV1-b v. UV2-b Analysis Input Goumn 1 Input Coumn 2 UV1-b	24.0 Para 2 Sample Rank UV1-b UV2-b N	Median Diff. Ha: Not squal to Contidence Mesthicen	- 0 0 0 0 0 0 0 0 0 0 0	0.114 0 0 0 95 1st Quarky 461 0 Rank Anaty s 0-value	lica Median GOU U	3rd Quartile 704 U upper 95%	910

2-day I-lest (E.col/)

		meters				
Analysis	2 Sampla !	Ho Mean Diff. = 0	0			
Pout Column 1	BG	Ha Not equal to 0	0			
Mout Courty 2	C-a	Confidence	0.8			
		Pocied Variance	FALSE			
		Descriptive Stat	elios	0.0221/2		
	N	Mean	Std Dev	Stut. E.t.		
Arc.	12	603.33	729.836	NNAME?		
C-#	12	0.00	0.000	#NAME?		
			Test Analy			
Mean Diff.	Sta, Err.	1	đ	p-value	kowar 90%	upper 90%
603.33	INAME?	#NAME?	INAME?	#NAME?	INAME?	INAME?
		Ho Mean Diff = 0	0			
Input Golumn 1 Input Golumn 2		Ha. Not equal to 0 Confidence	0.95			
		Confidence Pooled Variance	0.95 FALSE			
		Contidence	0.95 FALSE	Sud En		
nipul Golumi 2	UV1-a	Confidence Proted Variance Descriptive Stat	0.95 FALSE			
	UV1-a	Confidence Popled Variance Descriptive Stat Mean 1,145.00	0.95 FALSE	INAME?		
Hispuil Goldonni 2 BG	UV1-a	Confidence Proted Variance Descriptive Stat Mean 1,145.00 0.00	0.95 FALSE Sto Dev 682.510 0.000 Test Analy	INAME?		
Hispuil Goldonni 2 BG	UV1-a	Conheence Proted Variance Descriptive Stat Mean 1,145.00 0.00 1	0.95 FALSE Sto Dev 682.510 0.000 Test Analy df	INAME?	tower 95%	

		melere				
Analysis	2 Sample 1	Ho: Mean Diff = C	0			
Input Courtril 1	BG	Ha Not equal to 0	0			
Input Column 2	UV2 a	Confidence	0 95			
		Pooled Variance	FALSE			
	Secolar Se Secolar Secolar Sec					
		Descriptive Stat				
	N	Mesari	Std Des			
BG	N 12		729.836	#NAME?		
BG UV2-0		603 33	729.836			
	12	603.33 0.90	729.836	INAME?		
	12	603.33 0.90	729.836 0.000	#NAME?	Kower 95%	upper 95%

a constant far take and	Parame	lers			120122-000	
Analysis		Mean Den. = 0	3			
input Column 1		Not equal to 0	0	•		
		ant-denue	0.9			
input Column 2		NOW!! Variance	FALSE			
	Pro Pro	NOING A SURVICE	FALSE			
		Descriptive Stat				
	N	Mean	Sid. Dev	Sut Fr		
BG	12	603.33		#NAME?		
C-0	12	0.00		INAME?		
6-6	14	0.00	0.000	BIRDONL.		
		1.	Test Analy			
Mean Diff.	Sid En.	3	dt	p-value	lower 90% up	
	INAME?	#NAME?	INAME?	INAME?	INAME?	INAME?
670.30				and the second states		
BG v. UV1-b						
	Perame					
		Mean Diff. = 0	0			
Input Column 1		Not equal to 0	0			
Input Column 2		ntidmae	0.9			
	Pt	wied Vanance	FALSE			
		105				
		Descriptive Stat				
	N	Medin	Std Dev.			
BG	6	1,145.00				
UV1-6	6	0.00	0.600	INAME?		
			Test Analy			
Means Diff.	Std En	1	ď		lower 90% u	
1.145.00	INAME?	INAME?	INAME?	SNAME?	INAME?	#NAME
BG v. UV2-b	Param					
		Muan Dift. = 0	0	1		
Analysis input Column 1		Not equal to 0	0			
		a Not equal to U	0.9			
Input Calumn 2			FALSE			
	Pe	solad Veriance	FALSE	1		
		Descriptive Stat	stice			
		Metr	Sid. Dev	Std. Err		
	N					
80		60.1 33	729 8.36	#NAME?		
BG	12	603.33		ENAME?		
BG UV2 b						
	12	603.33 0.00		ename?		
	12	603.33 0.00	0.000	INAME?	iower 90% u	DDer 90*

Gv.C-c	Paramatars
vialyes	
nput Column 1	BC He Not equal to 0 0
nput Column 2	C.c Contraence 0.95
	Pocied Variance FALSE
	Descriptive Statistics
-	N Mean Sid Dev. Std. Err
G	12 603.33 729.836 #NAME?
÷c	
Meen Diff.	1-Test Analysis Sid. Ett. t dt p-value kower 95% upper 95%
236 67	SIG. EII. I dt p-value kover 95% upper 95% INAME? INAME? INAME? INAME? INAME? INAME?
G v. UV1-c	
	Perameters 2 Sympler I Ho Mean Off = 0
nalysis tout Column 1	
put Column 2	
	Pooled Vanance FALSE
	Descriptive Statuctics N Meen Std. Dev. Std. Err. 6 1.145.00 682.810 4NAME?
G	6 1.145.00 682.810 INAME?
V1-c	6 405.00 238.726 INAME?
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Muan Diff. 315 83 2-day 1-taat (T BG v. C-a Analysis	Sid: Err 1 Frait Analysia Sover 95% upper 95% Sid: Err 37 prebule Sover 95% Upper 95% Sid: Err 37 prebule InnuL2
Muan Diff. 315 83 2-day 1-taat (T BG v. C-a Analysis	Skic Err 1 Fast Analysis Skic Err 0" prebus strukter 0" prebus strukter strukter strukter
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L-Test Analysis Mosn Diff. Sto En. I of p-volor lower 95% upper 96% 1.402.02 priaME1 #NAME? #NAME? #NAME? WAME? WAME?

 BG v. UV2-a
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 Input Column 2
 UV2-a
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Muan Didt.	Std Err.	1	et	p-value	kower 95% upper 95%
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Input Column 2	UV2-8 C	ornoe	0.95			
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nout Column 2	UV1-b C	onfidence	0.95			
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put Column 1	BG H					
put Column 1	BG H	0 OI IAUpu ION	0			
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	123.5		-Test Anat			
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INDUS COLUMN 2	UVI-C C	onhiderica	0.95			
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			Test Anal	-		
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I-Test Anatysis Milan Diff. Shi Err. 1. dt. (--ralue kower 95% upper 95% 285.42. ename? ename? ename? ename? ename? ename?

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		Descriptive Sta	tistics			
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UV1-a	8		43 704			
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8G v. UV2-a

BG UV2-A

Barses data only - E.coli (Mann-Whitney & I-test)

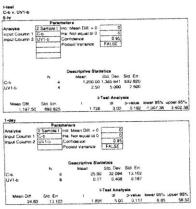
6-tur	1	BG	C-0	UV1-a	UV2-6	C-b	UV1-D	UV2-b		UV1-c	
Barnas	Bun 2-1	385	0	0	0	2400	0	0	2400	480	240
	Bun 2-2	366	0	0	1 12	2400	10	6	2400	2400	
	Bun 3-1	340	0	0	0	0	0	0	2400		296
	Bun 3-2								460	2400	
	Hun 3-2	900	0	0						1400	
1-day	Hun 3-2	1 900									
1-day	Hun 3-2	IBG	C-0	UV1-0	UV2-e	C-b	IUV1-6	UV2-6	C-c	UV1-c	
	Run 1-1				UV2-a	с.ь 0		UV2-6	C-c 1700	UV1-c 1700	1
1-day Barasa	I	BG	0	0	-		0	UV2-6	C-c	UV1-c 1700 1700	1

	Run 2-2 Run 3-1 Run 3-2	690 870 130		0	D	000	0	U	1430 110 -700	1700 1700 160	1700
2-day											
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Ba/844	Aun 1-1	BG 1750	C-0	UV1-# U	V2-0 C-b	0	C C	2-0 0	135	250 260	UV2-c

Run 1-2	1750	01	0		D	0	1	195	260	S
Run 2-1	1680	0	0	G	0	0	0	790	530	50
Bur 2-2	690	0	0	1	0	0	- 1	730	700	4 m 1
Bun 2-1	870	D	0	0.	C.	D	C	610	800	1750
Bun 3-2	130	0	0	100	3	D	- 1	1750	90]	

S-hr						
		meters				
		Ho. Madan Oilt = 0	0			
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Input Column 2	UV1-b	Contidence	0.95			
		1	criptive Statist			
					3rd Quartile	Manager and
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	001-6	j Den	cripitve Statist	ice .	5 <u>-</u> - 1475	1254-5425
	N	1	criptive Statist	Median	3rd Quartile	
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Input Column 2		Des Masanum	criptive Statist	Median 10	50	70
input Column 2 C-b LIV1-b	N	Des Meismum	criptive Statiss 1st Quartie 0 0 0 0 0 0 0 0	Median 10 0	50	70
input Column 2 C-b LIV1-b		Des Meismum S Mann-Whitne Hank Sutt2	criptive Statist 1st Quartie 0 0 0 0	Median 10 0 te sower 95%	50 0 upper 95%	70

2-day all 0's



Barasa	dete	only	-	Total	Collion	ns

UV1-e v. UV2-e

UV1-8 UV2-8

UV1-0 UV2-0

UV1-b v. UV2-b

 UV1-a v. UV3-a
 Parametera

 Ansiysa
 2.5ample1

 Timpo Courn 1
 UV1-a

 UV2-a
 Contentione

 Input Courn 1
 UV2-a

 Provided Vanance
 PALSE

UV1-b v. UV2-b Aratyska [2 Sample] Ho Meen Drt - 0 Insut Column 1 [UV1-b] Hat Not equal to 0 Insut Column 2 [UV2-b] Configence Pooled Vanence FALSE

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 Descriptive Statistics

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 38.75
 32.596
 #NAME?

t-Test Ansiyals

1-Test Analysis

Mean Diff Sid. Err. I dt D-value iower 95% upper 95% 296.45 #NAME? #NAME? #NAME? #NAME? #NAME? #NAME?

Mulan Diff. Std. Err. L. dl. D-value lower 95% upper 95% 8.75 INAME? INAME? INAME? INAME? INAME? INAME?

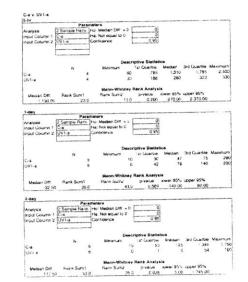
 Descriptive Statistics

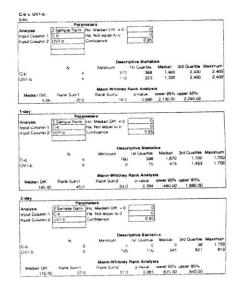
 N
 Mean
 Sid Dev
 Sid Err

 6
 409.33
 347.141
 FNAME?

 8
 111.85
 154.271
 FNAME?

	1	BG	C-0	UV1-a	UV2-	C-b	UV1-b			UV1-C	
Barnes	Bun 2-1	2400	1580	320	1010	2400	2400	2400		2400	240
	Bun 2-2	2400	2400	330		2400	2400		2400	2400	
	Bun 3-1	2400	1040	30	290	400	260	330		2400	472
	HU0 2-2	2400	60	240		270	110		2400	2400	
1 day		100	C-4	100	UV2-4	C. h.	UV1-b	IIV2.b	IC-c	UV1-c	UV2-0
	+	BG				1700			1700		
Barnas	Run 1-1	1700				1700			1700		£
	Run 1-2	1700			250	1640					170
	Run 2-1	1700		200		1700			1580		
	Run 2-2	1700		110	50			560			
	Run 3-1	1700							1700		
	Run 3-2	1700	10	0	1	160	20		1 1100	1 1700	





Creat holting , all 0's therefore no stat difference

day	7	BG	C.	UV1-e	UV2-0	C-b	UV1-b	UV2-D		UV1-C	
	Bun 1-1	1750	0	0		0	0		135	250	-
	Run 1-2	1750		0	1	0	1 0	d i	195	260	
	Bun 2-1	1680	0	0	6	0	1 0	0	790	530	50
	Run 2-2	690	0	0		0	0	1	730	700	
	Run 3-1	870		0	0	0	0	0 0	610	800	1750
	Bun 3-2	130		0		0	0		1750	90	

and the second		
	-	

-		BG
8.	Run 2-1	2400
	Run 2-2	2400
	Run 3-1	2400
1	Hun 3-2	2400

T UBY	-	IBG	C-4	UV1-0	UV2-4	C-b	UV1-b	UV2-b	C-c	UV1-c	UV2-0
Barnas	Bun 1-1	1700				1700	240		1700	1700	
	Bun 1-2	1700		47	1	1700	1700		1700	1700	
	Bun 2-1	1700		200	250	1640	1700	1700	1700	1700	170
	Bun 2-2	1700	290			1700	710		1580	1700	1
	Run 3-1	1700				250	0	560	1700	1700	170
	Bun 3-2	1700		0		160	20		1700	1700	

Barnas	Bun 1-1	1750	1750	5		50	835		1750	1750	
	Sun 1-2	1750	120	5		1750	105		1750	1750	
	Hun 2-1	1750	1750			D	910	0	1750	1750	
	Run 2-2	1750		100		0	580		1750	1750	
		1750			0	0	110	0	1720	1750	1756
	Run 3-1						110	1	1750	1750	
	Run 3-2	1750	130	1 0		U	1.10		1.00		

-10

C-b v. UV1-b

C-b UV1-b

C-b UV2-b

Mean Ditt.

C-6 v. UV2-6

 C-b-v. UV1-b
 Parameters

 Analysia
 2 Sample 1

 Input Coumn 1
 C-b

 Hes. Not equal to 0
 0

 Input Coumn 2
 UV1-b

 Commerce
 0.05

 Pooled Vanerce
 TRUE

 Parameters

 Analysis
 2 Sample I

 1 nout Column 1
 2.5 Ha Not equal to 0

 1 nout Column 2
 UV2-0

 Confidence
 0

 1 nout Column 2
 UV2-0

 Posted Variance
 TRUE

Descriptive Statistics N Mean Ski Dev Ski En. 8 300.00 710.634 #NAME? 6 408.33 347.141 #NAME?

 Descriptive Statistics

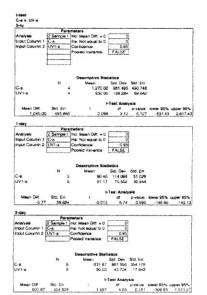
 N
 Mean
 Sid. Oev
 Sid. Err.

 12
 177.08
 496.357
 #NAME?

 8
 111.88
 154.271
 #NAME?

Neen Ditt. Sid En t dt p-value lover 95% upper 95% 65.21 ename? ename? ename? ename? ename? ename? 19.21 ename? ename?

I-Test Analysis Mean Ddl. Sid Err 1 d p-value lower 95% upper 95% 106.33 BNAME? BNAME? BNAME? BNAME? BNAME? BNAME?



	Parame	Lora				
Analysis	2 SATINE I INC			1		
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Input Column 2						
input column a		Millence	E 95			
	P	oind Vanance	FALSE			
	L]					
	-	Descriptive Sta	tatica			
	N	Manari	Std. Dev	Sat En		
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UV1-0	4	1,292.50	1,280 298	640 148		
			Test Anei	-		
Media Dill.	SALT EN.	1	al	p-value	kower 95%	Upper 95
75.0	0 875.126	0.000	5.97			
1-day						
	Paramet					
Analysia	2 Sample ! Ho		C			
Input Column 1		NOT equal to 0	C			
Input Column 2		indence	0.95			
	Poi	eonaria variance	FALSE			
		Neecriptive Stat				
	N	Mean -	Std Dev			
Ct		Moari 1.191 67	Std Dev 760 151	312.372		
C-6 UV1-6		Moari 1.191 67	Std Dev	312.372		
		Moar 1 1a/1 67 728 33	Std Dev 760 151	312 372 324 514		
		Moar 1 1a/1 67 728 33	Std Dev 765 151 794 894	312 372 324 514	lower 95%	upper 851
UVI-b	N 6 Ski En.	Moar 1 1a/1 67 728 33	Std Dev 765 151 794 894 Test Analy ul	312 372 324 514		
UVI-D Mean Diff 463.35	N 6 Ski En.	Moaur 1.1u1 67 728.33 1- 1	Std Dev 765 151 794 894 Test Analy ul	312 372 324 514		
Wean Diff.	N 6 6 5kd En 450 428	Moar 1 1 1 1 67 728 33 1 1 1 025	Std Dev 765 151 794 894 Test Analy ul	312 372 324 514		
UV1-0 Mean Diff. 463.35 2-day	N 6 6 5kd En. 450 428 Paramet	Moarr 1 1µ1 67 728 33 1 1 1 025	Std Dev 765 151 794 894 Test Analy ul	312 372 324 514		
Mean Diff. 463.35 2-day Analysia	N 6 6 8 Stid En 1 450 428 Paramet 2 Sample 1 Ho	Mean 1 141 67 728 33 1 1 1 025 Pra Mean Defi ~ 0	Std Dev 765 151 794 894 Teet Analy 41 9 92	312 372 324 514		
Mean Diff. 463.35 2-day Analysia Input Course 1	N 6 6 Std En 450.428 Paramet 7 Sample 1 Has	Mear 1 ta1 67 728 33 1 1 1 025 878 Mean Defi ~ 0 Not equal to 0	Std Dev 760 151 794 894 Teet Analy ul 9 99 0	312 372 324 514		
Mean Diff. 463.35 2-day Analysia Input Course 1	N 6 6 Stid En. 450.428 Paramet Z Sample I Hov C-D Har UVI1-b Cox	Mean 1 1a1 67 728 33 1 1 1 1 025 P/8 Mean Detl ~ 0 Not equel to 0 totem:re	Std Dev 760.151 794 894 Test Anely ul 9.92 0 0 0.55	312.372 324.514		
Mean Diff. 463.35 2-day Analysia Input Course 1	N 6 6 Stid En. 450.428 Paramet Z Sample I Hov C-D Har UVI1-b Cox	Mear 1 ta1 67 728 33 1 1 1 025 878 Mean Defi ~ 0 Not equal to 0	Std Dev 760 151 794 894 Teet Analy ul 9 99 0	312.372 324.514		
UVI-D Mean Diff 463.35	N 6 5 8 8 8 9 8 450 428 7 8 9 8 9 8 9 8 9 8 9 8 9 8 9 8 9 8 9	Mean 1 Jul 67 728 J3 1 Jul 67 728 J3 1 Jul 67 1 Ju	Sitt Dev 763 151 794 894 Teet Anely ul 9 99 0 0 0 0 0 0 5,145 FALSE	312.372 324.514		
Mean Diff. 463.35 2-day Analysia Input Course 1	N 6 5 5 4 50 428 Paramet 2 5 4 50 428 Paramet 1 4 50 428 Paramet 1 4 50 428 Paramet 1 4 50 428 Paramet 1 4 50 5 6 5 5 6 5 6 5 7 5 7 5 7 5 7 5 7 5 7 5	Mean 1 tul 67 728 J3 1 1 1 025 era Mean Dift = 0 Not equal to 0 tholenne med Vanance Descriptive Stati	Sid Dev 765 151 794 894 Ul 9 92 0 0 0 0.95 FALSE	312.372 324.514 ele 9.value 0.330		
UVI-5 Mean Diff 463.35 2-day Analysis Input Column 1 Input Column 2	N 6 8 5kd En 450 428 Paramet 2 Sample 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Mean 1. 141 67 728 33 1 1 1 025 rrs Mean Drtl ~ 0 Not equal to 0 Not equal to 0 Not equal to 0 Not equal to 0 Steam Hoters Hean Drtl ~ 0 Not equal to 0 Not eq	Std Dev 765 151 794 894 Teet Anely ul 9 99 0 0 0 0 0 0 5 5 ALSE	312.372 324.514 ele 9.480e 9.330 Sid. Err.		
Mean Diff. 463.35 2-day Analysia Input Column 1	N 6 5 5 4 50 428 Paramet 2 5 4 50 428 Paramet 1 4 50 428 Paramet 1 4 50 428 Paramet 1 4 50 428 Paramet 1 4 50 5 6 5 5 6 5 6 5 7 5 7 5 7 5 7 5 7 5 7 5	Mean 1 Jan 67 728.33 1 1 1 025 Pr6 Mean Drt ~ 0 Kot squal to 0 thosense wed Vanavce Descriptive Statil Mean 300.00	Sid Dev 765 151 794 894 Ul 9 92 0 0 0 0.95 FALSE	312.372 324.514 elf p-value 0.330 Std. Err. 290.115		

t-Teel Analysis Mean Diff Stit En 1 dt ⊃veixe lower 55% uppnr 95% 108.33 322.679 - 42.338 7.26 0.747 671.82 6115

C-b v. Uv1-b

t-test

5-hour	BG	C-	UV2-a 0	-	UV2-b	~ I	JV2-6
Run 1-1	115	5	0	0	0	55	20
Run 1-2	75	0	0	0	0	50	35
Run 2-1	55	0	0	0	0	30	4
Run 2-2	85	0	0	0	0	40	23
1-day							
Run 1-1	1 15	0	0	0	0	11	
Run 1-2	32	0	1	2	0	5	14
Run 2-1	12	0	0	0	0	4	12
Run 2-2	14	0	0	0	0	1	1
Run 3-1	2	0	0	6	0	2	1.4
Run 3-2	6	0		1	0		
Run 4-1	14	1	0	0	1	12	
Run 42	9	0	0	2	2	¥.	3
2-day							
Run 1-1	115	0	0	0	0]	15	7(
Run 1-2	75	0	0	D	0	50	64
Run 2-1	55	0	0	0	0	65	26
Run 2-2	85	0	0	0	0	35	34
Hun 3-1	10	0	o	0	0	5	55
Run 3-2	30	0	0	0	0	10	20

	Para	nelers				
Analysis input column 1 Input Column 2	2 Sampie Rank C-a	Ho: Mectan Dfl + 0 Ha: Not equal to 0 Confidence	0.95			
		Dest	iptive Statis	lice		
	14	Manamum	1st Quartile	Median	3rd Quartin	Maximur
C-#	4	0	0			
UV2-#	-4	٥	0	٥	0	8 - I
1-day		velers				
Analysis Input Column 1 Input Column 2	2 Sample Rank Variable 1	Heisere Ho: Median Diff. = 0 Ha: Not equal to 0 Confidence	0 0.95			
input Celuinn 2						
input Column 2	N	Descr	Iptive Statist		3rd Quartile	Maximum
Variable 1	N			Mechan	3rd Quartile 0	Maximum
	8	Minimum	1at Guartile	Mechan		Maximur
Vanabe 1	8	Mintmum 0	1at Quartile 0 0	Mechan 0 0	0	Maximur
Vanabe 1	87	Minimum 0 G Mann-Whitney Rank Sum2	1at Guartile 0 0 Rank Analys	Mechan U C Lis Nower 95%	0 0 upper 95%	Maximur



	Paratte	elers.					
Analysis	2 Sample 1 H	o: Mean Dift. +	01	0	E		
input Column 1	C-a H	a: Not equal to	u T	0			
input Column 2	UV2-4 C	ontidence	_	0.95			
		workens Variance	1	RUE			
			-				
	have represented						
		Descriptive S					
	N	Meen		Dev	Sid Err		
C-#	4	1.	25	2 500	1.250		
UV2-a	4	0.	00	0.000	0.000		
			I-Test	Anah			
Mean DSt	Std En.	1		dt	p-value	knwer 95%.	UDDer 955
1.25	1.250	1.0	00	5 00	G.356	-1 81	4.3
	Contract Service of						
1-day			_				
	Parame		-				
Analysis		o. Mean Diff. e		0			
		a Not equal to	۹ L	0			
Imput Column 2	Vanable 1 10	entidence		0.95			
		worked vanance	11	RUE			

Input Column 2		oled vanance	TRUE			
	10					
		Descriptive Stati Musci	Std. Dev.	Sid Err		
	N					
Variable 1	8	0.13	0.354	6 125		
Variable 1	8	6.13	0 354	0.125		
		۲	fest Analy			
Mean Diff	S4d. Etr	1	đi	p-value	iower 95%	upper 95%
0.0	6 0:77	0.000	14.00	1,000	-0.38	0.38

C-b v. UV-b 5-br. all 0's

	Parame				
Anatysia	2 Sumple I Ho	Mean Diff = 0	0		
ing sut Column 1	Vanaow 1 Ha	E Not equal to G	0		
Input Column 2	Variable 1 1Cc	ntidence	0.95		
	Po	oled Variance	THUE		
2					
		Descriptive Stat	stics		
	N	Mour	Std Dev	Sto Err	
Variable 1	8	0.63	0916	0 324	
Valation 1	в	0.38	0 744	0.263	

 Mean Def.
 Std. Err.
 i
 of
 presume lower 95% upper 65%

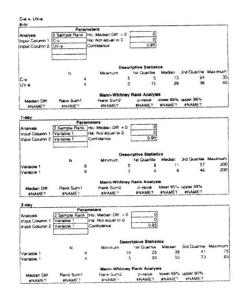
 0.25
 0.417
 0.599
 14.00
 0.599
 40.64
 1.14

 2-dery all 0*a
 1
 1
 1.4
 1.4
 1.4

Boston only - Total Collforms 5-hr

	BG	C-a	UV-a	C-b	UV-b	C-c	UV-c
Run 1-1	600	5	35	40	30	1000	1200
Run 1-2	1000	1 5	0	0	50	1600	1370
Run 2-1	1400	20	40	160	75	1400	1400
Hun 2-2	1400	35	20	110	110	1400	140
1-day							
Hun 1-1	150	12	7	12	11	240	24
Run 1-Z	150	23	8	16	28	270	280
Run 2-1	280	4	3	34	25	130	200
Run 2-2	240		5	28	17	170	320
Run 3-1	260	0	4	20	8	160	254
Run 3-2	220	6	3	15	δ	210	240
Aun 4-1	400	180	200	200	200	200	164
Run 4-2	280	200	160	200	200	280	320
Run 3-1 Run 3-2 Run 4-1	260 220 400	0 6 180	4 3 200	20 15 200		8 6 200	
400 180 200 280 200 160	180 200 200 160	200 160		200		00	00 200
7 60	0	25	15	60	65	5	600
1-2	1000				45		
tun 2-1	1400	25			455		15
Run 2-2	1400	15			40		100
Run 3-1	1300		85	95	215		1300
Run 3-2	1100	75	75	75	75	12:50	1300

111



Ce 4 0 20 30 84 110 Macro-Whitework Reak Analysis Macro-Whitework Reak Analysis 110 110 110 Macro-Whitework Reak Analysis Macro-Whitework Reak Analysis 110 110 110 Macro-Whitework Reak Analysis Macro-Whitework Reak Analysis 110 110 110 Macro-Whitework Reak Analysis Macro-Whitework Reak Analysis 110.4027 110.4027 110.4027 110.4027 Analysis 2 Samplin Territoria Inc. Macro-Diti = 0 0 0 0 0 Insul Courter 2 Samplin Territoria Inc. Macro-Diti = 0 0 0 0 0 Insul Courter 2 Waraba Territoria Constainer 0		Para	meters					
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N Minimum Ter Grames Meature Sol Cartille Meature CP 4 30 75 1/2	Septi Constant a	0.0	1					
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N Minimum Ter Grames Meature Sol Cartille Meature CP 4 30 75 1/2			De	ACTIO	Net Statist	ics		
CE 4 0 30 75 122 164 LVF 0 4 36 46 35 84 110 Mactain DB1 Rain (Sumits) Read Ametymis Read (Sumits) Read (Sumits) <td< th=""><th></th><th>N</th><th></th><th></th><th></th><th></th><th>3rd Querthe</th><th></th></td<>		N					3rd Querthe	
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1-day Persenters Analysis (2 Sangali Rana, Ino. Magan Dirt = 0 0 0) Input Courtry 1 (Varaba 1 - No. Nec exact to 0 0) Input Courtry 1 (Varaba 1 - Confidence Confidence Descriptive Statistics N Mannum 1 is Caution Median 3rd Charris Mannum N Mannum 1 is Caution Median 3rd Charris Mannum N Mannum 1 is Caution Median 3rd Charris 10 70 70 70 70 70 70 70 70 70 70 70 70 70								
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Descriptive Statistics N Maximum 1st Quartile Median 3rd Quartile Maximum 76 20	stvAME? 1-day Analysis	Pan 2 Sample Rank	analers Ho: Median Diff =		0	INAME?	INAME?	
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N Minimum 1st Quartue Median 3rd Quartue Maximum	INAME? 1-day Analysia Input Column 1	Per 2 Sample Rank Variable 1	anAME? amelers Ho: Median Diff = He, Not equal to 0		0	INAME?	INAME?	
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Manin-Whitney Rank Analysis Median Ditt. Rank Sum1. Hank Sum1. presult Sover (55% upper (55% eNAME? ENAME? ENAME? ENAME? ENAME? ENAME? ENAME?

Manin-Whitiney Rank Analysis Madan Dift Hank Sum1 Rank Sum2 priatue fower 95% uppor 95% eriAME? eriAME? eriAME? eriAME? eriAME? stiAME?

0 0 0 95

 Descriptive Stallatics

 Menmum
 1al Quantie
 Mudian
 3rd Quartie
 Maximum

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 33
 50
 71
 95

 40
 50
 70
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 455

Parameters Analysis [2 Sample Rank, Thin Mecken Diff = 0 Input Column 1 Vanable 1 Ha: Not equal to 0 Input Column 2 Vanable 1 Contubence

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2-day

Variable 1 Variable 1

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		Constant of the second s			
	Descriptive			10	
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UV-m	4 3	23 75 17 970 PPLAN	027		
		I-Test Analysis			
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Maun Diff	INAME? INAME?	INAME? INAL	ET INAMEY	FNAME?	
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1-day					
	Parameters				
Analyse	2 Sample ! No Mean Diff.	-0 0			
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	Pooled Varian	CO TRUE		1	
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	N Meen	Std Dev Std.	En	1	
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v ariatore -				1	
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Mean Diff	Sid Err I		Aust kower 95%	upper 95%	
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2-day					
	Parameters	0		1	
Analysia	Variable 1 Ing Not south				
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imput countri a	Poored Varian	THUE			
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LiTest Anarysis Meen Drtt Stal Err 1 uit prisible toeki 56% upper 95% 95.00 Instante? Intrade? Intrade? Intrade? Intrade? Intrade?

Constants

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dt [s] =	600	D (m) = 0.08	$A_{so}(m^2) = 0.005$	M [g] = 1000	٤ [•] =.	09	0.7	0.7 emissivity	
T, [K] = 2	291.15	x [m] = 0.0005	$A_{sc}[m^2] = -0.053$	$k_{\rm p} [{\rm W/mK}] = 0.2$	ρ[-] =	0	0.1	0.2 reflectivity	
		L= 0.21	$A_{x}[m^{2}] = 0.017$	C, [J/gK] = 4.2					

	Input						Calculat fully pair		le						nted bot	le					clear b				,			(w
time step	time	T[oC]	T. [K]	R [J/s-n	U [m/s]	QL	Q _{t(p)}	Q _{c(p)}	Q _{b(p)}	Q _{T(p)}	dT _p [K]	T _{n(p)} [K]	T _{n(p)} [°C]	Q _{rth})	Q _{c(h)}	Q _{te(b)} (a rini	dT _h [K]	Г _{п(h)} [K]	Tm(h) [°C]	Q _{r(c)}	Q _{c(c)}	Qu(c)	Q _{T(c)}	dT _c [K] 1		[OC]	<
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2	9.20		292.42	650.0	3.80	23.96	10.92	-17 51	21 82	-4 45	-0 64	292.97	19 82	9 83	1	17 05	14 13	2.02	295.69	22.54 24.18	4.37	-1 29		1 10 10	1.40	295.58	22.43	
3	9 30		293.05	650.0	3.80	24.17	10 92	-2 70	21.71	10.68	1 53	294.49	21.34	9.83	1	17.51	11 53 9 63	1.65	297.33 298 71	25 56	4 37	-3 68		0.000	1 08	296 66	23 51	
4	9:40		293.68	650.0	3.80	24.38	10.92	-13.08	22 11	0.12	0.02	294.51	21.36 22.42	9.83		17.90	9 03 8 25	1 18	299.89	26.74	4 37	-4 43		100.000	0.97	297 63	24 48	0
5	9.50	1	294.32	650.0	3 80	24.59	10 92	-5 89	22.16	7 47 2 37	1 07	295.57 295.91	22.42	983	1. 10	18 51	7 26	0.000	300.92	27 77	4 37	-1 99		1	0.89	298 51	25.36	
6	10 00		294 95	650 00	3.80 3.80	24 81 24 93	10.92	-9.02	22 45 22 56	5 11	0.73	296.64	23.49	10.58		18 76	6.98		301 92	28 77	4 70			10.000 (200)	0.83	299 34	26.19	
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16	11.40	30.3	303.48	917.3	3.80	27 80	15 41	-6.84	24 92	11.45	1.64	304 93	31.78	13.87		20 99	9 47	1 10 0001	310.85	37.70	6.16			1	1 31	306 96 308.37	35.22	7
17	11:50	31.9	305.07	909.2	3.80	28 39	15.27	-7 42	25.45	10 79	1.54	306.47	33.32	13.75	1	21 36	10.01	1 43	312.28	39.13	6.11	-4.32		1	1 40	309.84	36 69	2
18	12 00	33.5	306.65	901.00	3 80	28.98	15.14	-6.92	25.98	11.23	1 60	308.07	34.92	13.62		21.76	10.39		313 77 314 97	40.62	6.00	1.			1	311 05	37.90	Q
19	12.10	33.3	306.43	892.5	3.80	28.90	14 99	-17.31	26.45	0 13	0.02	308 09	34 94 34.55	13.49			5.54		315 77	42 62	5.94			1		311 87	38 72	second if
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22	12:40	32.6	305.78	858.5	3.80	28.57	14.42		26.17	-1.29	-0 18	307.09	33.94	12.98		22 92	0.77	0 11	316 63	43 48	5 77	-11 44	21.87	1 03	0 15	312.84	39.69	ō
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25	13:10	31.4	304 55	745.2	3 80	28.20	12.52	-21.32	26.00	-6.61	-0.94	305.89	32.74	11 27	-19 30	22.95	-2 78	-0.40	316 23	43 08	5.01			-1.69	-0.24	312 63	39.48	3
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29	13:50	28.2	301.35	325.8	3.80	27.03	5 47	-14.40	24 77	-6.67	-0.95	302.06	28 91	4 93	1		-9.27	1	311.95 310.53	38.80	1.49	1.100.000			1 2 2 3	308 58	35 43	-
30	14:00	27.4	300 55	221 00	3 80	26.74	3.71	-12.68	24.47	-6 69	-0.96	301 10	27.95	3.34		21.62	-9 94 -8.49		309.32	36.17		-13 68	100 million (1997)	-640		307.66	34.51	В
31	14.10	27.0	300.18	208.3	3.80	26 61	3.50	-8.42	24 19	-2.50	-0.36	300 75 300 34	27.60 27.19	296		1	-7.06		308.31	35.16	1 31				1	306.88	33.73	σ
32	14:20	26.7	299.82	195.7	3 80	26.48 26.35	3.29	-8 54 -8.09	24 08 23.95	-2 84 -2.61	-0.41	299.97	26.82	2 77	1	20.65	-6.04		307 45	34.30		-12.08				306.20	33.05	
33	14 30	26.3	299.45 299.08	183.0	3.80	26.33	2.86	-8.02	23.83	-2.77	-0.40	5 Grossee 6 6 7 6 6	26.42	2.58		4 1	-5 31		306.69	33.54	1.14	-11 56	20.11	-4.30	-0.61	305.59	32 44	ο.
34	14:40	25.9	299.08	157.7	3.80	26.10	2 65	-7.70	23.71	-2.66	-0.38	299 19	26.04	2.38		20.23	-4.78	-0 68	306.01	32.86	1 06	-11 15	1995	-3.95	-0 56	305 02	31.87	3
35	15:00	25.2	298.35	145 00	3.80	25.97	2 44	-7.55	23.59	-2.73	-0 39	298.80	25.65	2.19	-12.51	20 05	-4.40	-0.63	305 38	32.23	0 97	-10.83	19.80			304.50	31.35	Ð
37	15 10	24 5	297.65	130.8	3.80	25.73	2.20	-9 20	23.46	-4.74	-0.68	298.12	24.97	1.98	-12.37	19 89	-4.55	-0.65	304 73	31 58		-10.86				303.93	30.78	1
38	15:20	23.8	296 95		3 80	25.48	1.96	-9.49	23 24	-5.29	-0.76	297.37	24.22	1 76	-12 49	19.72	-4 96		304 02	30 87	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	-11.13		1		303.31	30.16	D
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40	15:40	22.4	295.55	88.3	3.80	25.01	1.48	-8 86	22.79	-5 17	-0.74	295 93	22.78	1.34		19.34	-5 45	1	302 49	29 34		-11 36				301.93	28 78 28.05	
41	15.50	21.7	294.85	742	3.80	24.77	1 25	-8.44		-4 99	-0.71	295 22	22.07	1 12			-5.60	1 (Storage Storage	301.69	28.54		-11.38	0.05300			301.20	27.30	
42	16:00	21.0	294.15		3.80	24.54	1 01	-8.30		-5 11	-0 73	294.49	21.34	0.91	0.0000000	18 94	-5 71		300 88		0.40	-11 35	1			299 83	26.68	
43	16.10	21.1	294.22		3.80	24.56	0.88	-3.51	22.16		-0.03	294.45	21.30	0.80			-4 75		300 20 299.71	26.56	0.30	1 122733			1 1000000	299 39	26.24	
44	16:20	21.1	294 28		3.80	24.58	0.76				0.12	294.57	21.42	0.69			-3.30		300.52	20.50	0.26	1	1			300.18	27 03	
45	16:30	21.2	294 35		3.80	24.60	0.64	-2.95	22.19	0.10	0 01	294.59 294.67	21.44	0.5		18.51	5.17		301.26	28.11	021	1.	10.10000000		1 No. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	300.90	27 75	
46	16.40	21.3	294.42	1 1000000	3.80	24.63	0.52	-2.34		0.60	0.09	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	21.52	0 35	-		4 73		301 93		0.16				0.67	301.57	28 42	
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APPENDIX III: Bottle Water Temperature Model

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Definition of terms

- Constant Inputs:
 - dt = time step interval [hours]
 - T_i = initial water temperature [K]
 - D = bottle diameter [m]
 - x = bottle thickness [m]
 - A_{sc} = $2\pi(D/2)L$ = total surface area of bottle cylinder $[m^2]$
 - $A_{se} = \pi (D/2)^2$ = total surface area of bottle end [m²]
 - $A_x = D^*L = cross sectional area of bottle [m²]$
 - M = mass of water [g]
 - k_p = thermal conductivity of plastic [W/mK]

Measured Inputs:

 T_a = ambient air temperature at each time step [K]

- R = net radiation measurements at surface for each time step [W/m²]
- U = wind speed at each time step [m/s]

Calculated:

 Q_L = amount of long-wave radiation going into the system $Q_L = \epsilon \sigma T_s^{-4} (A_{se} + A_{sc})$

where σ = Stefan-Boltzman constant (5.67*10⁻⁸) T_a = ambient air temperature

 Q_r = amount of heat generated by radiation absorbed by bottle $Q_r = \epsilon RA_x$

where ε is the percent of radiation absorbed by the system (clear = 80%, half painted = 90%, painted = 100%)

Q_b = amount of heat lost by back radiation

 $\mathsf{Q}_{\texttt{b}} = \epsilon \sigma \mathsf{T_s}^4 (\mathsf{A}_{\texttt{se}} {+} \mathsf{A}_{\texttt{sc}})$

where σ = Stefan-Boltzman constant (5.67*10⁻⁸) T_{s-ave} = surface temperature (calculated in attached spreadsheets)

 Q_T = net heat flux into bottle

$$Q_{T} = Q_{r} + Q_{c} + Q_{L} - Q_{b}$$

dT = change in temperature for each time step for either painted or clear bottles) $dT = (Q_T/C_vM)^* dt$

 T_n = final temperature for each time step (for either painted or clear bottles) $T_n = T_{(n-1)} + dT$

Painted bottles: conduction/convection

Constants

 $\label{eq:kp} \begin{array}{l} k_p \left[W/mK \right] = 0.2 & (thermal conductivity of the plastic) \\ D \left[m \right] = 0.08 & (bottle diameter) & L \left[m \right] + 2 \mbox{ (rool dimension)} \\ x(m] = 0.0005 & (bottle thickness) \\ A_{sc} = 0.005 \\ A_{sc} = 0.0528 \end{array}$

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ne ste			T ₁ [K]	v [m²/s]								Q _{tre}		T		Qr.tr	U	[m/s] Rep	+	NU _{le} . turt		Qia	Nute	Titc		an	Tsinve	QT
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3	292 97	292 73		9E-06			0 0034	0.325	15009	5 4 4 7 7	1007000000	-0 002	4.372		-0.017	-0.05		3.80 818529	1	1094		-0.214	159.41	100000000000000000000000000000000000000	-2 251	-2.68	292 91	1
4	294 49	293 37	293 93	9E-06	3E-05	0.0249	0 0034	0.3263	70995	7 7331	294 48	-0.014	6 4132	294.49	-0 118	-0 145		3.80 809123	1	1085.4		-1.035	158 74	1.10.000	-10.86	-12 93	294 23	
5	294.51	294	294 25	9E-06	3E-05	0.0249	0.0034	0.3267	31841	6 4332	294.51	-0 005	5 2481	294.51	-0 044	-0 054		3 80 806333	100000000000000000000000000000000000000	1082.8		-0 46?	158.53	0.000		-5 835	294 39	
6	295.57	294 63	295.1	1E-05	3E-05	0.025	0.0034	0 3277	57987	7.3806	295 57	-0 011	6 0964	295.57	-0 094	-0 116		3.80 799125	196.51	10762		-0 864	158 01	295.15	-9.068	-108	295 36	
7	295.91	295 13	295.52	1E-05	3E-05	0 025	0 0034	0.3282	47590	7.0528	295.91	-0 009	5 8024	295.91	-0 074	-0 091		3 80 795620	196.19	1073		-0.714	157.76		-7.5	-8.928	295 73	
8	296 64	295.5	296.07	1E-05	3E-05	0 025	0 0034	0.3289	68962	7.6885	296.64	-0.014	6.3732	296.64	-0 12	-U 147		3.80 791081	1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2	1068.8		-1 045	157 42	296.12	-10.98	-13.07	296.38	
9	296.88	295.87	296.37	1E-05	3E-05	0.025	0 0034	0.3292	60907	7.4698	296 88	-0.012	6.1767	296.88	0 103	-0 127		3.80 788593		1066.5		-0.928	157.24	0000000		-11 61	296 65	- I
10	297.46	296 23	296.85	1E-05	3E-05	0.0251	0.0034	0 3298	72840	7 7905	297.45	-0 015	6.4651	297 45	-0 13	-0.16		3 80 784750	195.19	1062 9	296.9	-1.12	156.96	296 9		-14	297.18	
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12	298 31	296 97	297 64	1E-05	3E-05	0.0251	0 0034	0.3307	78490	7.9315	298.3	-0.017	6 5922	298.3	-0 146	0 179		3 80 778387	194 59	1057	297 7	-1 224		297.7		-153	298	
13	298 70	297 94	298 32	1E-05	3E-05	0.0252	0.0034	0 3314	43988	6.9353	298 7	-0 008	5 6974	298.7	-0.072	-0 089		3 80 772962	194 08	1051 9		0 695	156 08	1010000000000		-8 683	298 53	-
14	300.09	299 53	299.81	1E-05	3E-05	0.0253	0 0033	0.3331	31837	6.4487	300.09	-0.006	5.2624	300 09	-0.05	-0.061		3.80 761451	192.99	1041.1	299.84	-0 516	155 21	299 84	1	-6.453	299.96	
15	301.80	301.11	301.45	1E-05	3E-05	0.0254	0.0033	0 3349	37513	6 6969	301.8	-0.007	5.4843	301.8	-0 063	-0.078		3.80 749103	191 8	1029 4		-0.626	154 26			-7 828	301 64	
16	303.29	302.69	302.99	1E-05	3E-05	0.0255	0.0033	0.3366	31628	6.4475	303 29	-0.006	5.2616	303 29	-0.053	-0 065		3 80 737917	190.71	1018 8	303.02	-0.542	153 39	0.0000000000000000000000000000000000000		-6 779	303 16	- E
17	304 93	304.28	304.6	1E-05	3E-05	0.0256	0.0033	0.3383	33351	6.5291	304.93	-0.007	5.3346	304 93	-0.059	-0.072		3 80 726561	189 59		304 64	-0 588	152.5	304 64		-7 35	304 78	
18	306.47	305.86	306.16	1E-05	3E-05	0.0257	0.0033	0.3399	30262	6 3916	306 47	-0 006	5.2119	306.47	-0 054	-0 067		3 80 715870	188 52	997.62	306.2	0 548	151 65	306.2	-5 754	-6 85	306.33	
19	308.07	306 54	307.31	1E-05	3E-05	0 0258	0 0033	0 3411	74127	7.8571	308.06	-0.019	6.5261	308.07	-0.169	-0.208		3 80 708241	187.75	990 23	307.39	-1 368	151 04	307.39	-14.37	-17 11	307 73	
20	308 09	306 33	307 21	1E-05	3E-05	0.0258	0.0033	0.341	85644	8.1293	308.08	-0.023	6.7713	308.08	-0 203	-0 249		3.80 708897	187 82	990.87	307.31	-1 578	151.09	307.31	-16.57	-19.73	307 69)
21	307 70	306 11	306.9	1E-05	3E-05	0.0258	0.0033	0.3407	77549	7.9398	307.69	-0.02	6.6005	307 69	-0 178	-0.218		3.80 710918	188 02	992.83	306.99	-1 422	151.25	306 99	-14 93	-17.77	307 34	
22	307.58	305.89	306 73	1E-05	3E-05	0.0258	0.0033	0.3405	82340	8.0525	307.56	-0.022	6.702	307 57	-0.191	-0 235		3 80 712052	188 14	993 92	306.83	-1 505	151 34	306.83	-15 81	-18 82	307.2	1
	307.28	305.68	306 48	1E-05	3E-05	0.0258	0.0033	0 3402	78643	7 9648	307 27	-0.02	6 623	307 27	-0.179	-0.22		3 80 713781	188.31	995 6	306.56	-1.432	151.48	306 56	-15 03	-17 89	306.91	
	307.09		306 27	1	3E-05	0 0257	0.0033	0 34	80533	8 0089	307.08	-0.021	6.6627	307.08	-0 184	-0.226		3.80 715128	188 45	996.9	306 36	-1.461	151.59	306.36	-15.34	-18.26	306.72	
1072274	306.83	304.95	305 89	1E-05	3E-05	0.0257	0 0033	0 3396	93443	8 2949	306.82	-0.025	6 9206	306 82	-0.22	-0.27		3 80 717724	188.71	999 41	305.99	-1 684	151 8	305 99	-17 68	-21.05	306 41	1
26	305 89	304.15	305.02	1	3E-05	0.0257	0.0033	0.3387	87748	8.1691	305 88	-0.023	6.807	305.88	-0.199	-0 244		3 80 723683	189 3	1005.1	305 11	-1.558	152 27	305.11	-16.36	-19 48	305.49	1
10.000	304.92	303 35	304.14			0.0256		0.3378	80774	8.0077	304 91	-0.02	6.6614	304 91	-0 176	-0.216		3.80 729816	189 91	1011	304.22	-1.413	152 76	304 22	-14 83	-17.66	304.57	1
	303.97	302 55	303.26			0.0255					303.96	-0 018	6.5182	303 96	-0.155	-0.191		3 80 736001	190.52	1017	303 33	-1.28	153.25	303.33	-13.44	-16	303 65	
0.000	303 01	301.75	302 38			0 0255			67114		303	-0 015	6.3491	303.01	-0 134	-0.165		3.80 742325	191 14	1023	302 45	-1 139	153.74	302 45	-11.96	-14 23	302 73	
	302.06	300.95	301 5	1 1		0 0254			60024	7.4612	302.05	-0.013	- CO (22) (CO	302 05	-0 114	-0 14		3 80 748734		1029 1	301.56	-1.003	154.23	301 56	-10 53	-12 54	301.81	
1000	301.10	1. States 1. State	300 73			0.0254			40451	6 8108	301.1	-0 008	5.5861	301.1	-0.068	-0.084		3 80 754456	192 32	1034.5	300.77	-0.667	154.67	300.77	-7.001	-8 335	300.94	
	300 75	300	300 37			0.0253			41280		300.74	-0 008				-0.086		3 80 757176	192.58	1037.1	300.41	-0 676	154 88	300 41	-7 099	-8.451	300.58	
100000	300 34	299.63	299 99			0.0253			39390		100 A 100 A 100 A	-0.008			-0.065	-0.08		3.80 760103		1039 8	300 02	-0.641	155.11	300 02	-6 728	-8 009	300 18	
	299 97		299 62			0.0253			39323		299.96	-0 007			-0 064	-0.079		3.80 762925		1042 5	299 65	-0.635	155 32	299.65	-6 672	-7.943	299.81	
1000	299.57	299.27				0.0252		0.3325	1.	6.7102	299.57	-0 007	5.496		-0 061	-0 075		3.80 765854		1000000000		-0.61	155.54		1 1	-7 624	299.42	
1000	299.37		299.24		3E-05		0.0000	0.3321	37508		299 19	-0 007	5 4774	299.19	-0.06	-0.074		3.80 768747	1 1 1 1 1 1 1 1 1 1			-0 598	1	298.89		.7 475	299.04	
	299.19	290.55		1		0.0252	100 100 100 100 100 100 100 100 100 100		46085	7.01	298.8		5 7643		1	-0.094		3.80 772356	1	1.		-0 729	1.000	298 44		-9 109	298.62	
	298.00	290				0.0252	0.0034		48109				5.8246		-0 079	-0.098		3.80 777796				-0 751	156.44			-9.392	297.94	
	298.12	297.3				0.0251	0.0034		1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	6.9869			5.7435		-0 073	-0.09		3 80 783632		100000000000000000000000000000000000000		-0.702	156 87	100000000000000000000000000000000000000		-8.777	297 19	
	1.000.000	295.9			3E-05		0.0034		46125	7.0048			5 7594		-0.073	-0 089		3 80 789335		1067 2		-0.702	157.29	1.1.1.1.1.1.1.1.1.1.1.1		-8 775	296 49	
	296.67	295.9			3E-05		0.0034		44485		295.93	-0.008			-0.068	-0.084		3.80 795274	100000000000000000000000000000000000000	1072.7			157.73	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1	-8 352	295.76	
1000	295.93			1	1.100000000		0.0034		0.0000000	6.9374	1000000	-0.008			-0.067	-0 082		3.80 801197						294.89		-8 219	295.05	
	295 22	294.5			3E-05				18949		293.21	-0.003	• • • • • • • • • • • • • • • • • • •		-0.023	-0 028		3.80 805642		1082.2	1.	-0.278	1.	0.0000000		-3.478	294.42	
267.224	294 49	294.18			3E-05				1.12121212101		12.1.1.1.2.0.1.2.2		1			-0.017		3 80 805495		1082.1		-0 187	158.47			-2 342	294.41	
1000	294.45	294.25	294 35				0.0034			5.2642		-0.002							100000000000000000000000000000000000000	1081.4	10.12.010.12.01	 10000 (2000) 	158.42	0.00000000000	100000	-2 927	294.51	
1000	294.57	294.32		1			0.0034		1 AVACES AND			-0.002			-0 019	-0 023		3 80 804709		0.0000000000			158.42	2023		-2.325	294.51	
0.000	294.59	2003/01/2017					0.0034		12632		294.58	-0.002	4.2006			-0 017		3 80 804364	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			-0.203	158.39	10000000		-2.525	294.62	- I -
12149	294.67	294.45	1.2.2.1.7.7.7		3E-05		0.0034		13787	10000000000	294.67	-0 002	1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -		-0 016	-0 019		3 80 803717			294.57			1.200 0.0000	1 1			
		294.52		1	3E-05		0.0034			5 1869		-0 002	4.1416			-0 016		3.80 803279		Aug. 201	294 62		158.31	1.	•	-2.194	294.66	
49	294.78	147 28	221.03	2E-06	1E-05	0 0 1 98	0 0045	0.148	1E+08	48.763	290.46	-8.674	44.5	290.83	-83.33	-100.7		3 80 4E+06	1 203.00	1 5101 8	201.78	-16/	247.43	201 78	-1963	-2337	246 21	1

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Half-painted bottles: conduction/convection

Constants

 $k_p [W/mK] = 0.2$ (thermal conductivity of the plastic) D [m] = 0.08 (bottle diameter)

x[m] = 5E-04 (bottle thickness)

A_{se} = 0.005

 $A_{sc} = 0.053$

alculations (free convection)											(forced convection)																	
me step	T IKI	T. [K]	T, [K]	v [m²/s]	(m²/s)	W/mi	3 [K']	Pr	Ra _D	Num	Tatre	Qire	NUtre	Ta-tro	Que	Q1-1e	U (m/s)	Reo	Nu.	NU1. tur	Taile	Q _{te}	Nute	Tarle	Qic	Q1-1	Tarava	QTA
1	291.15	291.5	291.3	9E-06	3E-05	0.025	0.003	0.323	21137	5.865	2912	0.003	4 742	291.2	0.024	0.03	3 80	33294	39.9	84.26	2912	0.039	31.34	291.2	0 408	0 486	291 2	0.51
2		292.1	292.9	9E-06	3E-05	0.025	0.003	0 325	1E+05	8 403	293.7	-0.02	7.017	293.7	-0.179	-0.22	3.80	32729	39 65	83.28	293.6	-0.191	31.15	293.6	-2.005	-2.387	293 6	-2 60
3	295.69	292.7	294.2	9E-06	3E-05	0 025	0 003		2E+05	9.735	295 7		8 224	295.7	-0.396	-0 485	3.80	32269	39 44	82.48	295 5	-0.358	31	295 5	-3 758	-4.474	295.6	-4.95
4	297 33	293.4	295.3	1E-05	3E-05	0.025	0.003		2E+05	10 42	297 3	-0.064	8 842		0 574	0.702	3.80	31883	39.27	81.8	297 1	-0 478	30 87	297.1	-5 024	-5 981	297 2	-6 68
	298.71	294	296.4	1E-05	3E-05	0.025	0.003	0 329		10.82	298 7	-0 079	9.21	298.7	0711	-0.87	3.80	31550	39.11	81.22	298.4	-0.566	30.75	298.4	-5 94	-7.071	298.5	-7 94
121	299 89	294 6	297 3	1E-05	3E-05	0 025	0 003	0 33	3E+05	11.07	299.8	-0 091	9 442	299.8	-0.816	-0.998	3.80	31256	38.97	80.7	299 6	-0.629	30 65	299.6	-6 604	-7.862	299.7	-8 85
	300.92	295.1	298	1E-05	3E-05	0.025	0.003	0.331	3E+05	11 31	300 9	-0.103	9.655	300 9	-0 921	-1.126	3 80	31011	38 86	80 26	300.6	-0.691	30 57	300 6	-7 257	-8 64	300 7	-9.76
	301.92	295.5	298.7	1E-05	3E-05	0.025	0.003	0.332	4E+05	11 57	301.9	-0 117	9.895	301.9	-1 049	-1 282	3.80	30797	38 76	79 88	301.5	-0.764	30.49		-8 026	-9.555	301.7	-10.8
	302.86	295 9	299.4	1E-05	3E-05	0 025	0 003	0.333	4E+05	11 78	302.8	-0.13	10 09	302.8	-1 166	-1.425	3.80	30595	38 66	79.52	302 4	-0.83	30 42	302.4	-8714	-10 37	302 6	-11
	303.75	296.2	300	1E-05	3E-05	0.025	0.003	0.333	4E+05	11 97	303 7	-0.142	10.26	303.7	-1.276	-1.559	3 80	30403	38 57	79.18	303 3	-0.89	30.35	303.3	-9 344	-11.12	303.5	-12.6
11	304.60	296 6	300 6		3E-05	0.025	0.003	0.334		12.13	304.5	-0 153	10.41	304.5	-1 381	-1 688	3 80	30218	38 48	78 84	304.1	-0.946	30 29		-9 932	-11 82	304 3	1.
3.3	305.44	297	301.2		3E-05	0.025	0.003		5E+05	12.27	305.4	-0.164	10 54	305 4	-1.483	-1.811	3 80	30039	38 4	78.52	304 9	1	30.22	304 9	-10 49	-12.49	305.2	-14
	306.26	297.9	302 1	1E-05	3E-05	0.025	0 003	0.336	4E+05	12.16	306.2	-0 16	10 44	306 2	-1 445	.1.766	3.80	29775	38.27	78 04	305 8	-0 977	30.13		-10.26	-12.21	306	1
	307.15	299.5	303.3		3E-05	0 026	0.003	0.337	4E+05	11.83	307.1	-0 143	10.14	307.1	-1.292	-1 578	3.80	29418	38 09		306.7	-0.892	30	306 7	-9.365	-11 15	306 9	
	308.25	301 1	304.7	1E-05	3E-05	0.026	0.003	0.338	4E+05	11.57	308.2	-0 132	9 894	308 2	-1.185	-1 449	3.80	29041	37.91	76.71	307.8	1 (1993) 100	29 86			-10.39	308	
16		302.7	306.1	1E-05	3E-05	0.026	0.003	0.34	3E+05	11.36	309.4	-0.124	9.702	309.4	-1.112	-1.36	3.80	28654		76	309.1	-0 786	29 72	309 1	-8 274	-9 851	309 3	1 20000
17		304.3	307.6		3E-05	0.026	0.003	0 341	3E+05	11 19	310.8	-0.118	9 547	3108	-1 062	-1.298	3.80	28262	37.52	75.28	310.5	-0 757	29.57	310.5		-9 468	310.6	
	312.28	305.9	309 1	1E-05	3E-05	0.026	0.003	0.343	3E+05	11.05	312.2	-0.115	9.421	312.2	-1 027	-1.257	3 80	27872	1.	74.55	311.9		29.42	311.9		-9 198	312 1	-104
	313.77	306.5	310.2	1E-05	3E-05	0.026	0.003	0.344	3E+05	11.33	313.7	-0.132	9.675	3137	-1.19	-1.455	3.80	27598		74 04	313.4	10 C C C C C C C C C C C C C C C C C C C	29.31	313.4	-8 657	-10.31	313.5	-11.7
	314 97	306 3	310 6	10.000	3E-05	0.026	0.003	0.344	4E+05	11.83	314.9	-0.166	10 13	314 9	-1.494	-1 825	3.80	27474	37.11	73.81			29 27			-12.32	314 7	1
	315.77	306.1	310.9		3E-05	0 026	0.003	0.345	4E+05	12.15	3157	-0 19	10.43	315.7	-1.717	-2.098	3.80	27403		73 68		1.	29.24	10.000		-13.74	315 4	
	316 25	305.9	311.1	1E-05	3E-05	0.026	0 003	0 345	5E+05	12.36	316.2	-0.208	10 62	316 2	-1.877	-2.293	3.80	27369	1 10.00 A 10.00	73.62			29 22	3157		-14 74	315 9	
	316.52	305.7	311.1		3E-05	0.026	0.003	0.345	5E+05	12.51	316 4	-0.22	10 75	316 4	.1.99	-2.43	3.80	27363		736		1 1 1 1 1 1 1 1 1 1 1	29.22	100000000		-15.43	316.2	
	316 63	305.5	311	1E-05	3E-05	0 026	0.003	0 345	5E+05	12.6	316 5	-0.228	10 84	316.5	-2 066	-2.523	3.80	27376	1 100002263	73.63		-1.272	29.23	316		-15.9	316 3	
25		305	310.8	1E-05	3E-05	0 026	0 003	0 345	5E+05	12 76	316.5	-0.242	10.99	316.5	-2.187	-2 67	3.80	27439	1	73 75	316	1	29 25	316		-16.63	316.2	1
26	316 23	304.2	310.2	1E-05	3E-05	0.026	0.003	0.344	6E+05	12 91	316.1	-0.252	11.12	316 1	-2.285	-2.79	3.80	27588		74.03	315 5	1.	29 31	315.5		-17.24	315 8	1
	315.48	303.4	309.4	1E-05	3E-05	0.026	0.003	0.343	6E+05	12.96	315.4	-0 254	11.17	315.4	-23	-2 808	3.80	27784		74.39	314 8		29.39	2011 2023 107	100000000	-17.35	315	-20
	314.47	302.6	308.5		3E-05	0.026	0.003	0.342	6E+05	12.96	314.3	-0 249	11.17	314.4	-2.254	-2 751	3.80	28016	1	74.82	313 8	 1000000000 	29 47	1000000000	1	-17 1	314.1	
	313.28	301 8	307.5	1E-05	3E-05	0.026	0 003	0.341	6E+05	12.9	313.2	-0 239	11 12	313.2	-2.164	-2.642	3.80	28275		75.3	312.6		29.57	312.6	1.	-16.6	312 9	
	311.95	301	306 5		3E-05	0 026	0.003	0.34	5E+05	12.81	311.8	-0.226	11.03	311.9	-2.044	-2 495	3.80	28558	1	75.82	311 3		29.68	1 100 100 100 100	10000000	-15 9	3116	
31	310 53	300.4	305.4	1E-05	3E-05	0.026	0.003	0.339	5E+05	12.61	310 4	-0 205	10.85	310.4	-1.852	-2.262	3 80	28829		76.32	309.9		29 78	1 2 2 2 3	 10.00 (20.00) 	-14 75	310 2	2 CO CO
32	309 32	300	304 7	1E-05	3E-05	0.026	0.003	0.338	5E+05	12.38	309 2	-0.184	10 63			-2 029	3 80	29046	1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	76 72	308 8		29 86		E. 17 C.C.	-13.56	309	1000
33	308.31	299.6	304	1E-05	3E-05	0.026	0.003	0.338	4E+05	12.19	308.2	-0.168	10 46	1.1.200.00		-1 856	3.BO	29239		77.07	307.8		29.93	10000		-12 66	308	
34	307 45	299.3	303.4	1E-05	3E-05	0.026	0.003	0.337	4E+05	12.04	307 4	-0.157	10.33		1 1	-1.725	3.80	29413	1 2 2 2 2 2 2 2 2 2	77.39	307		30	1	-10.05	-11.96	307 2	
35	306.69	298.9	302 8	1E-05	3E-05	0.025	0 003	0.336	4E+05	11.92	306 6	-0 147	10.22	306.6	-1 328	-1.623	3 80	29574		77 68			30 05			-11.41	306	
36	306.01	298.5	302.3	1E-05	3E-05	0.025	0.003	0.336	4E+05	11.83	305.9		10 13	1	1 1	-1.542	3.80	29725	38 24		1 - 00 - 00 - 00	1	30 11	305.6		-10 97	305	
37	305 38	298	301.7	1E-05	3E-05	0.025	0.003	0 335	4E+05	11 82	305.3	-0.138	10.12			-1.519	3.80	29895	38 33	-	1.252		30.17	304.9		-10.85	305	1
	304.73	297.3	301	1E-05	3E-05	0.025	0.003	0.334	4E+05	11.88	304.7	-0 139	10 18	1		-1.534	3 80	30095	38.42		304.3		30 24			-10.95	304.	
39	304.02	296.6	300.3	1E-05	3E-05	0.025	0.003	0.334	4E+05	11.91	303.9	-0.139		1 44403400		-1.534	3.80	30306	1 2010/12/201		- 312-000		30.32	303.6				
40	303 27	295 9	299.6	1E-05	3E-05	0.025	0.003	0.333	4E+05	11.93	303 2	-0.138	10 23			-1.523	3.80	30527	38 63	1	 4.100 (10) 	1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	30.4	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	1 1 2 19 19 20 1	-10.93	303	1
41	302.49	295.2	298.8	1E-05	3E-05	0.025	0 003	0.332	4E+05	11.94	302.4	-0 137	10 23	0 00006510	-1.232	-1 505	3 80	30755		1000000000	302.1	-0.867	30.48		-9.108	-10 84	302.2	
42		1 12 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	298.1	1E-05	3E-05	0.025	0 003	0.331	4E+05	11.94	301.6	a contractor	4 Contract			-1.481	3.80	30990			301 3		12200223	1 285802	1 1 2 2 2 2 2 2 2	-10 73	301.4	1
	300.88		297.5	1E-05		0.025	0.003	0 331	4E+05	11.76	300.8	-0.123	10 06			-1 354	3 80		1		1.10103334					+10	300.0	
	300.20	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	297 2	1E-05	3E-05	0.025	0.003	0 33	4E+05	11.43	1 15 23 23 3	-0.106	9.764	 Chick Strict 			3.80	31268			299.8					-8.902	300	
	299.71	294 3	297		3E-05	0.025	0.003	0.33	3E+05	11 16	299.7	-0.094	9 522				0.00	0	0	1 5	2997		0.3	299.7	0	0	299	
	300.52	1.	10002023		1.1010121311	0.025	0.003	0.33	4E+05	11.5	300.5	-0.11	9.835			-1.213	0.00	0		1	300 5	1 2	0.3		0	0	300.5	
47			297.9		3E-05	0.025	0 003	0.331	4E+05	11.79	301.2	-0.126	10 1	301.2		-1.383	0.00	0		1 332	301 3	a a	03	1 2 2 2 2		0	301.2	
	301.93				3E-05	0.025	0.003	0.331	4E+05	12 03	301.9	-0.14	10.31	301 9		-1 54	0 00	0		1	301.9	1	03	1	0	0	301.9	
	302 55					0.02	0 004	0 166	9E+07	47 18	298.1	-8.961	43 03	298.	-86.03	-104	0 0 0	Q	0	0	302 5	0	0.3	302.5	0	0	1 300 4	1 -1

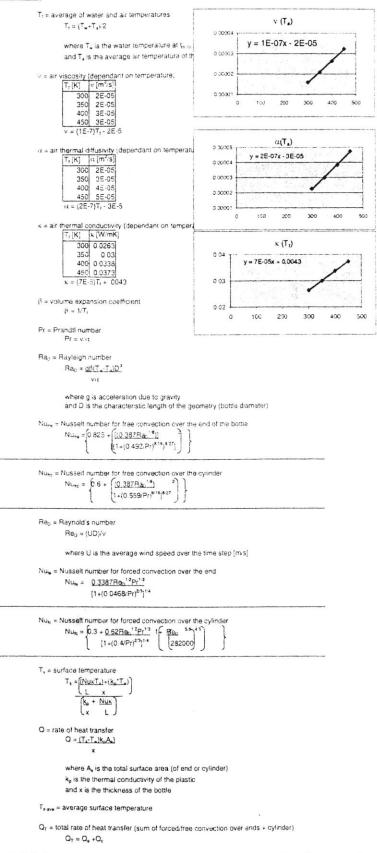
Clear bottles: conduction/convection

Constants

Calculations

Calculations		(free convection over end				(forced convection over end						
time st T. (K) T. (K) T. (K) V [n	$m^2/s \alpha (m^2/s \kappa (W/m \beta (K^{-1}) Pr$	Rao Nune T.	tre Qtre M	NUtre Tatre (Dire QT-tr	U [m/s] Reo Nu		Qie	Nuic Turte	Q _{ic} Q _{1-t}	Tstave	Q _{1-t}
	E-06 3E-05 0.0247 0.0034 0.32	31 21137 5.8649 29	1.15 0.0029 -	4.7419 291 15	0.0244 0.0301		901 84 263 291			Contraction and the second	291.16	0.516
2 292 89 292 1 292 49 9E	E-06 3E-05 0.0248 0.0034 0.32	46 51159 7.1609 29	2.88 -0.009	5.899 292.88	-0 075 -0 093		712 83 525 292		31.197 292 84	-1.008 -1.2	292 86	-1 293
	E-06 3E-05 0.0248 0.0034 0.32	58 102145 8.4264 29	4.33 -0.021	7.038 294.33	-0 184 -0 226		547 82 887 294		31 075 294 24	-2 048 -2 438	294.28	2.665
	E-06 3E-05 0.0249 0.0034 0:	27 137923 9 0611 29		7.6121 295 56	-0 275 -0.337		401 82.325 295		30 967 295 44	-2.81 -3.345	295.5	-3.682
5 296.66 294 295.33 1E	E-05 3E-05 0.025 0.0034 0.3	28 162991 9 4402 29		7 9558 296.64	-0.346 -0.424		268 81 816 29		30 869 296 5	-3.368 -4.01	296 57	-4.434
6 297.63 294.63 296 13 1E				8.1759 297 61	-0 402 -0 492		146 81.349 297			-378 -45	297 53 298 4	-4.992
7 298 51 295 13 296.82 18	E-05 3E-05 0.0251 0.0034 0.32			8.4133 298 49	-0 467 -0 572		041 80.948 298		30.701 298.31	-4 256 -5 066 -4 827 -5 746	298.4	6418
8 299 34 295.5 297.42 1E		04 225637 10.236 29		8 6787 299 32	-0 549 -0 672		951 80.607 299		30 634 299 11 30 572 299 85	-4 827 -5 746	299.21	7.07
9 300.10 295 87 297.98 1E	E-05 3E-05 0.0252 0.0034 0.33			8 8794 300 07	-0 619 -0 758	3.80 31026 38			30 512 299 85		300 65	-7 631
	E-05 3E-05 0.0252 0.0033 0.33			9 0379 300.77	-0.681 -0.833	3 80 30858 38 3 80 30698 38					301.3	-8 125
	E-05 3E-05 0.0252 0.0033 0.33			9 1678 301 43	-0737 -0901		638 79 428 301				301 92	-8 571
	E-05 3E-05 0.0253 0.0033 0.33			9 2778 302 06	-0 787 -0.963		523 78 994 302				302 55	-7.928
	E-05 3E-05 0.0253 0.0033 0.3			9.0639 302 68	-0.717 -0.877 -0.562 -0.688		354 78.365 303				303.33	-6 487
		35213197 10 1 12 30		8 5669 303 44 8 1641 304 45	-0 458 -0.562		171 77 683 304		30 055 304 27		304 36	
	E-05 3E-05 0 0255 0 0033 0 3			7.8456 305.63	-0.389 -0.477		978 76 969 305		29 912 305 48		305 55	-4 789
	E-05 3E-05 0.0256 0.0033 0.3				-0.344 -0.422		778 76 237 306		29,763 306 81	-3 272 -3 895	306 88	4 317
	E-05 3E-05 0.0257 0.0033 0.3			7.5998 306.95			576 75 498 308		29.613 308 22	-3 038 -3 617	308 29	1
	E-05 3E-05 0.0258 0.0033 0.3-			7.4148 308 35	-0.315 -0.386		432 74.975 309		29 505 309 65	-3 979 -4 737	309 73	
				7.9255 309 82	-0 698 -0 855		366 74 735 310		29 456 310.78		310 9	4
	E-05 3E-05 0.0259 0.0032 0.3			8.6969 311.02	-0.895 -1.095		327 74.593 311				311 68	-9 343
	E-05 3E-05 0.0259 0.0032 0.3			9.1528 311.82	-1 041 -1 274		307 74 522 312			-7.808 -9.296	312 17	-10 57
	E-05 3E-05 0.0259 0.0032 0.3			9.4454 312.33	-1.148 -1.404	3.80 27844 37			29.408 312 29		312 46	-11 44
	E-05 3E-05 0.0259 0.0032 0.3			9.641 312.63	-1 224 -1 497		306 74 518 312		29.411 312 41	-8.871 -10 56	312 59	1
	E-05 3E-05 0 0259 0.0032 0 3			9 7748 312 78	-1.34 -1.638		337 74 63 312		29.435 312.42	-9.532 -11.35	312 61	-12 99
	E-05 3E-05 0.0259 0.0032 0.3			9.9746 312.81	-1 463 -1 787		406 74 879 312				312 35	
	E-05 3E-05 0.0259 0.0032 0.3			10.308 312.04	-1.528 -1.866		493 75 196 311			-10 59 -12 61	311 82	-14 48
	E-05 3E-05 0.0258 0.0032 0.3			10.374 311 33	-1.55 -1.894	3.80 28417 37		0.9 -1.022	29 626 310.9	-10.73 -12.78	311.11	.14 67
	E-05 3E-05 0.0258 0.0033 0.3			10 398 310 48	-1 541 -1 883	3 80 28638 37			29 709 310 05	-107 -12.74	310 26	-14 62
	E-05 3E-05 0.0257 0.0033 0.3	339435035 12 111 30		10 392 309 53	-1.51 -1.845	3 80 28876 37		9 1 .1.005	29.798 309.1	-10.55 12.56	309 31	-14 41
				10.284 308 51	-1 415 -1 729			8 1 -0.956	29 881 308.1	-10 04 -11.95	308 3	-13.68
0.000.000.000.000.000.000.000				10 125 307.6	-1.298 1.587		025 77 142 307	22 -0 895	29 947 307.22	-9 394 -11.18	307.41	-12 77
	E-05 3E-05 0.0256 0.0033 0.3 E-05 3E-05 0.0255 0.0033 0.3			10 002 306 83	-1.212 -1.481	3.80 29441 38	105 77 438 306	46 -0.848	30 006 306.46	-8 906 -10 6	306 64	1 -12 08
	E-05 3E-05 0.0255 0.0033 0.3			9 9065 306.15	-1.146 -1.401	3 80 29591 38	179 77 712 30	5.8 -0.813	30.061 305 8	-8.534 -10.16	305.9	-11 56
	E-05 3E-05 0.0255 0.0033 0.3			9.8331 305.53	-1.096 -1.339	3 80 29733 38	248 77 969 30	52 .0785	30.113 305.2	-8.244 -9.815	305.36	6 -11 15
	E-05 3E-05 0.0254 0.0033 0.3			9.7759 304.97	-1 056 -1 291	3 80 29869 38	314 78 215 304	64 -0 763	30.162 304 64	-8 015 -9 542	304.8	1 -10 8:
	E-05 3E-05 0.0254 0.0033 0.3			9 8033 304.44	-1.058 -1 294	3 80 30025 3	8 39 78 497 304	.11 .0 766	30.218 304 11	-8.039 -9.57	304 28	8 -10 86
		334 365348 11 563 3		9.8897 303 88	-1.089 -1.331	3 80 30214 38	481 78 836 303	54 -0 784	30.286 303.54	-8.231 -9 799	303.7	1 -11.13
	E-05 3E-05 0.0253 0.0033 0.3			9 9515 303 26	1 105 -1 351	3.80 30414 38	577 79.196 302	91 -0.795	30.357 302 91	-8.344 -9.934	303.08	8 -11 29
	E-05 3E-05 0 0252 0.0033 0 3			9.9959 302 58	-1.113 -1.36	3.80 30624 38	677 79 573 302	24 -08	30.431 302 24	-8 401 -10	302 4	1 -11 36
	E-05 3E-05 0.0252 0.0033 0.3			10 028 301 88	-1.113 -1.36	3.80 30843 3	8.78 79 963 301	.53 -0.801	30.508 301.53	8 -8 415 -10.02	301	7 -11 38
				10.051 301 15	-1.108 -1.354	3.80 31068 38	887 80.365 30	80- 80	30 587 300 8	-8.4 -10	300.97	7 -11 35
	IE-05 3E-05 0.0251 0.0034 0.3 IE-05 3E-05 0.0251 0.0034 0.3			9.8978 300.4	-1 02 -1.246		966 80 666 300	.08 -0.75	30.646 300 08	-7 875 -9.376	300 24	4 -10 6
		33 330167 11.253 2		9 6057 299.79	-0 88 -1 077			9.5 -0.668	30 677 299.	-7.018 -8.355	299 6-	1 -9 432
	1E-05 3E-05 0 0251 0.0034 0.3			9 3747 299 36	-0.782 -0.956	0.00 0	0 0 299	39 0	0 3 299 3	0 0	299.37	
		303 341179 11.347 3			-0 923 -1 129	0 00 0	0 0 300	18 0	0 3 300 18	8 0 0	300 15	
		307 376959 11.639 3		9.9583 300 85	-1.057 -1.292	0.00 0	0 0 30	0.9 0	0.3 300.9	0 0	300.87	
	1E-05 3E-05 0.0252 0.0034 0.3			10 184 301.52	-1.184 -1.447	0.00 0	0 0 30	57 0	0 3 301.57	0 0	301 54	
	2E-06 1E-05 0.02 0.0044 0.1	655 9E+07 47 244 2				0.00 0	0 0 30	2.2 0	0.3 302.2	0 0	300 07	-1038
43 302 20 147 20 224.74 2		ood actor a caste				n 9 h	st 1.					

Definition of terms



Source for Pr, Re, Ra, and Nu: Incropera, F.P. and D.P. DeWitt 1996 Fundamentals of Heat and Mass Transfer, Fourth Edition. John Wiley & Sons, New York, NY

plots of model v. real data for data collected in Barasa

			1	
	Painted			
Time	Actual	Model	diff1	StDev1
0	293.9	295.91	2.01	1
1	302.8	298.70	-4.10	3
2	308.6	308.07	-0.53	0
3	310.9	306.83	-4.07	3
4	308.9	301.10	-7.80	6
5	305.2	298.80	-6.40	5
6	301.7	294.49	-7.21	5
7	298	294.78	-3.22	2
Second				-

		Clear			
	Time	Actual	Model	diff1	StDev1
	0	292.6	298.51	5.91	4
	1	298.3	302.71	4.41	3
,	2	301.8	309.84	8.04	6
	3	303.6	312.87	9.27	7
	4	303.5	308.58	5.08	4
	5	301.4	304.50	3.10	2
	6	298.8	300.45	1.65	1
	7	296	302.20	6.20	4
	h			_	4
		Half			
	Time	Actual	Model	diff1	StDev1

	nau			
Time	Actual	Model	diff1	StDev1
0	294.8	300.92	6.12	4
1	303.8	306.26	2.46	2
2	309.2	313.77	4.57	3
3	311	316.63	5.63	4
4	310	310.53	0.53	0
5	306.3	305.38	-0.92	1
6	302.4	300.88	-1.52	1
7	298.4	302.55	4.15	3
				2

