Health Impacts of Water Pollution in Yay Oakkan, Myanmar

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Assessment of Health Impacts of Water Pollution in Hlaing Tharyar Industrial Zone:

A Case Study on Yay Oakkan Village Group

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EXECUTIVE SUMMARY

In this area, the villagers can't get sustainable access to safe clean water is a major problem in the study area, Yay Oakkan Village Group in Hlaing Thar Yar Industrial Zone. Hence, the waste water disposed by the factories is an important factor for the region to consider when they suffer from the diseases. In this area, the residents have to use the four sources of water such as Lake-Water, Tube-well Water (90 feet, Tube-well Water (400 feet) and Joe-phyu Water.

This study aims to expose and provide to be able to reduce the health impacts of impurity water and wastewater disposal mainly by industries in Hlaing Thar Yar Industrial Zone. The study estimates the water and other causes which can affect the human health. It was exposed by analyzing the determination of background information, quality of water and awareness about water pollution and health habits. And also it was evaluated the level of awareness of the health problems among the people who suffer from the water pollution caused by the industry by using the systematic sampling method for data collection and testing the water quality and parameters in the hot season and the rainy season.

The findings show that the residents suffer from the (22) diseases and face the problems which does not get the sufficient clean water for their daily use due to the households survey. In accord with the water test, it is found the parameters which can harmful the human health such as turbidity, ammonia-nitrogen (NH_3N), Cyanide, alkalinity, iron and chloride mainly in the Tube-well water (90 feet). The diseases of dizziness, headache, fever, diarrhea, skin problems, asthma, nausea, typhoid, cholera and cramp are mostly related to the Tube-well water (90 feet), diseases caused by industry and distance of water sources from the industry and they can explain about (74%) of the variation in medical expenses.

1.0 INTRODUCTION

1.1 A Brief Background History of Hlaing TharYar Township

Hlaing TharYar Township was established in 1985. Hlaing TharYar Township has an area of 26.01 sq miles and it is an administrative area of Northern Yangon Division. This township is situated on the west bank of Hlaing River, and it is surrounded in the east by Insein

Township, on the west by Htantapin Township, on the south by Twantay Township and Panhlaing River, and in the north by ShwePyitha Township. There are 20 wards, 9 village tracts and 18 villages in HlaingTharYar Township.

Industrial zones have been established in HlaingTharYar Township since 1995. Now, the total number of factories is 588 in industrial zones. The industrial zones had been carried out by the Management Committee, which was formed on 24.7.1996 and maintenance fees are collected Ks.10000 for per acre / month from local investors and USD 50 for per acre/month from foreign investors.

1.2 Population

In 2009, the total population of HlaingTharYar Township is 340876, people that 164152 are males and 176724 are females. It has 55826 households and 73349 families. There are 340778 Myanmar nationals and 98 foreigners in this township. Myanmar nationals living in the township are Kachin, Kayah, Kayin, Chin, Bamar, Rakhaine, Shan and other nationals. Majority of people in the township are Bamar with 323497 people making up the 94.9% of the total population of the township, the second largest nationals are other races, 11222 people making up the 3.3% of the total population of the township, the third largest number of people is Kayin, 2739 people making up the 0.8% of the total population of the township. There are 23 Chinese 23.5% of the total numbers of foreigners living in the township: 73 Indians are 74.5% of the total number of foreigners living in the township. 2 Pakistanis are 2% of the total number of foreigners living in the township; Among them, there are 329371 Buddhists, 96.6% of the total population of the township; 7280 Islam, 2.7% of the total population of the township; 5399 Christians with 1.6% of the total population of the township; and 2652 Hindus with 0.8% of the total population of the township; 3452 Islam with 1.0% of the total population of the township.

1.3 Occupation

In HlaingTharYar Township, people earn their living by working as day and night shift workers in factories. There are businessmen, farmers, and general workers.

1.4 Research problems

HlaingTharyar Industrial Zone is bounded by Hlaing River in the east, ShweThanLwin Industrial Zone in the west, Pan Hlaing River in the south and Yangon Pathein Road in the north. It was established on 15th February 1995.The objectives of this Industrial Zone are (a) to create job opportunities and increase incomes of the people in the region,(b) to further enhance the social and economic development of national economy, promoting local and foreign investment and technology through industrial sector.

The total area of land is (1401.98) acres and (1087.98) acres has been used as the Industrial area. There are (588) operating factories in this Industrial Zone. There are different types of factories such as Garment, Food-Stuff, Toiletry, Construction Materials, Electrical Goods, Forest Products, Chemical Products, Press-related, Machinery Parts, Cold Storage, Grain and General.

These industries have not only exploited the natural resources to their maximum but also the discharge of toxic effluents and emissions from harmful industries have also polluted the surrounding environment. Water is one of the most important industrial materials required in the manufacturing process, and so many industries are established around the water bodies. These industries pollute the water resources by discharging toxic effluents causing health hazards to living beings.

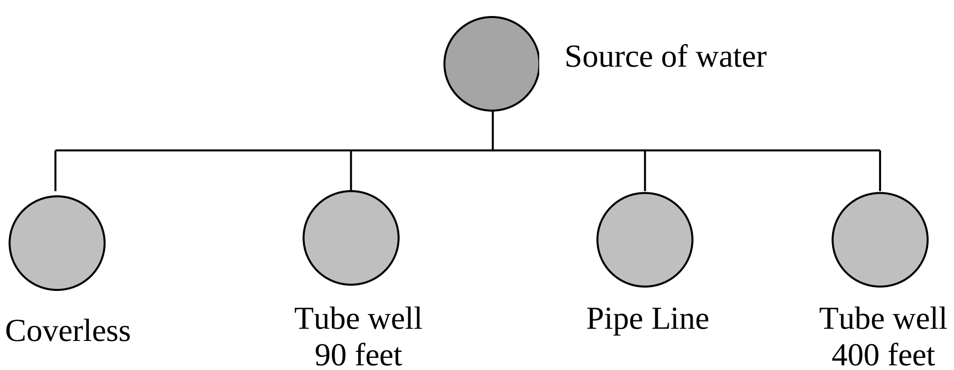
Water is the basic and primary need of all living processes. Water pollution is one of the serious problems for beings. Waste waters can be contaminated by feed-stock materials, by-products, product material in soluble as particulate form, washing and cleaning agents.

The shape of the HlaingTharYar Industrial Zone is in square shape and there are totally four villages near the zone. Two are outside the zone and another two are inside the zone. There are over (40) streets in the whole zone. Each street has (2) ditches which length is over two miles at left and right side. These ditches are being used for (588) factories to dispose their wastewater. So many gallons of wastewater are disposed daily through these ditches.

In HlaingTharYar Industrial Zone, the Zone Management Committee which was formed on 24th July 1996 has to carry out for the development of this Industrial Zone. Since establishing this zone, the responsible body did not serve the exact direction, laws and regulation for disposing wastewater and treatment for the water. So, all the factories except a few factories which obey the international standard have to dispose their wastewater themselves arbitrarily and they do not cost extraordinarily for their water treatment. Besides, no one knows exactly how much the volume of wastewater releases from these industries daily.

Although many areas are suffered from the health impacts caused by impurity and wastewater disposal from HlaingTharYar Industrial Zone, this study is focused on Yay Okkan Village Group in HlaingTharYar Industrial Zone which was selected for three reasons. Firstly, this area is suited in the center of Industrial Zone. Secondly, there are no proper sewage and drainage system which can expose the waste-water from the factories in this area. Thirdly, there is no sufficient clean water for drinking and other uses.

Yay Oakkan Village Group is situated beside Yangon-Pathein Highway, between HlaingTharYar Industrial Zone (3) and (4) in the North of Pan Hlaing River. The area of this village is (1.64685) square miles. The two villages: ThaungGyi Lay village and Yay Oakkan village consist of this village group. The total population is (41759) people and there are (4410) households and (2829) houses. Their main occupations are factory workers, vendors, trishaw drivers, manuals and small retailer shops. Most of the people are low-income group and according to the villagers' income level although it is divided into four main sources of using water, the pipe-line water, the tube-well water (90 feet) , the tube-well water (400 feet) and the coverless lake water, most of the people have to use the tube-well water because water supply supported by the government is not enough for all villagers. Moreover, the two-third of the population who is low-income group, can't use the pipe-line water sufficiently because of it is more expensive than the tube-well water and the cost of this water has been increasing year by year. So, those people have to use mainly the tube-well water (90 feet) for their water sources.



Before 1997, the water source of this village, a tube well of 90 feet depth is not suitable for the human health because of its geographical situation and this water naturally contains iron, calcium and salinity. So, they have to rely on not only tube-well water but also other water sources for their livelihood. Before 1997, there were about (2000) people in this village and they could also get the water from two natural lakes. The water from these two lakes could provide enough water for their daily use.

According to the saying of the local villagers who have lived in this area before industrial zone and the members of Community Peace and Development Committee, after the establishment of the industrial zone, urbanization has been taken place and there is over population, causing the depletion of one of the lakes for drinking water. Urbanization also causes the degrading of water quality for consumption. However, not only pipe-line water can't be sufficiently supported to the required water for the whole area but also the villagers are to buy with money. Because of the government does not supply the pipe-line water to the villagers directly. The government directly supplies the water to the factories which has been officially allowed to use and the villagers have to pay fees through these factories. So, low income people can only rely on the pipe-line water for their drinking and they use the tube-well water for their other uses.

Besides, the villagers also suffers from water pollution because of the factories in the Hlaing Thar Yar Industrial Zone dispose the waste water, chemical and other byproducts into the small creeks and the Pan Hlaing River.

There are about (170) various kinds of factories around the Thaunggyi Lay Village Group and they are around this village track. Some of the factories such as chemical factory, dying factory, detergent powder factory, cold storage factory and so on are disposing their wastewater unsystematically through the ditches around them into the Pan Hlaing River.

Especially, one of the dyeing factories in this area disposes hot wastewater volume of (10000) gallons daily. This wastewater includes color, acid and chemical according to the testing of Yangon City Development Committee.

Some villagers who live near this dyeing factory have to walk in this water and they suffer from the skin problems. Although there are ditches with the depth of (12) feet for releasing the wastewater from various industries, the wastewater can't flow easily due to the bad drainage system. Then sedimentation up to (11) feet occurred which makes the flow worse. Another problem is the depletion of Pan Hlaing River since 2010. Because of these two problems, the wastewater can't flow quickly into the Pan Hlaing River.

In this village track, water pollution has been growing after 2008 caused by the rapid population growth and industrialization. Before 2008, there were (10) tube wells in this village group, (5) tube wells can be used for drinking water. But after 2008, the more factories were established, the more the volume of water disposed by various industries.

These effects of waste water disposed increased from industries can impact the tube-well water in this area indirectly because the color, taste and smell are gradually getting worse and worse compared to the situation in 1997. In the wet season, the color and smell of water significantly changes and it is not suitable for their daily use. So, the villagers suffer from the infection of cholera, diarrhea, typhoid, skin problems and others infectious diseases caused by impurity of water and disposed wastewater.

Based on the results mentioned above, it is hoped that our study would provide strong evidence to justify the dire necessity of support to get clean water cheaply for the people living in this area. Because they have to incur the health costs that are caused by coming into contact with contaminated water if they do not get the clean water in the long run. This study can be used by policy makers and government organizations, non-government organizations and international non-government organizations involved in reducing these problems in the areas of wastewater is disposed systematically, education the ways of using water to protect the health problems and protection the environmental problems caused by industrialization as minimum as possible in the future.

Until quite recently, the pollution of natural water was not much of a problem, but with rapid urbanization and industrialization, this problem is reaching alarming proportions. In this area, industries discharge their untreated or only partially treated sewage and industrial wastewater into neighboring ditches. In doing so, they create intense pollution in ditches and rivers and expose the people who live in surrounding area to dangerously unhygienic conditions especially in the rainy season, this wastewater cannot flow rapidly and flood in through the streets.

1.5 Significance of the Study

In this area, wastewater and chemicals from the factories are increasingly discharged into the ditches and rivers unsystematically. It can lead to degradation and pollution of water, air and soil. As well as the government can't provide enough water supplies for the whole area and the villagers have to use the impurity water consist of various chemicals because they can't afford to buy clean water all the time, except for their drinking. So, the villagers have suffered from the infectious diseases, causing loss of income or high expenditure for health.

Without attention to the existing pollution problems that underpin water resources use within this area, the life quality of the villagers can exacerbate. Thus, understanding how water pollution might harmful to the human health and environment is necessary as long as they use these water sources. This result will be useful to analyze the direct and indirect costs on health from declining water quality.

1.6 Policy Context

Myanmar is one of the developing countries in the world, and very little information is available regarding the nation's water quality.

No single institution is responsible for the overall management of Myanmar's water resources. Currently, the Ministry of Agriculture and Irrigation is the main Ministry involved in water resources, with the mandate to develop agriculture and irrigation. Urban water supply systems in Myanmar are generally very out -of-date, with only intermittent supply and poor water quality. The water supply system in Yangon operated by the Water and Sanitation Department of the Yangon City Development Committee provides piped water to probably 40% - 50% of the urban population.

The infrastructure of water distribution needs to be developed due to the country's further economic development. In Myanmar, the water quality testing of ground water is undertaken by Yangon City Development Committee but water management is a lack of appropriate monitoring facilities, proper and systematic keeping of records, regular monitoring and surveillance data for water quality control and basis standards of water quality for drinking water.

Although there are many laws, acts, legislations and regulations related to water sector, most laws and acts for water sectors still need to be modified. In this area, Yangon City

Development Committee is mainly responsible to monitor water quality in those water bodies where wastewater is discharged to regulate and to monitoring wastewater from the industrial zone.

Though the Management Committee of the Industrial Zone has to collect the maintenance fee (ks-10000) for per acre/month from local investors and (USD 50) for per acre/month from foreign investors for all-round development and has also to do monitoring the wastewater disposal especially cleaning the sediment in the ditches, they can do just one time per year.

To solve this problem, the Yangon City Development Committee built the main water distribution center in this area and the tube-well water is filtered by Reverse Osmosis System. And then the four pipe-lines were settled for free distribution this water into the village. Although Yangon City Development Committee has to pay these charges, now this system has stopped because of higher charges.

As well as, the Department of Health has been curing and providing the medicines for the infection of Cholera, diarrhea disease, typhoid, skin problems and other infectious diseases which more occur at the beginning of the raining season. Especially, during the disease occurs, this department has been curing, giving and distribution the vaccines and education not to drink impurity water, to drink boiled water to keep the meal systematically, to be clean in the house and surroundings.

1.7 Objectives of the study

Overall objective of the study is to analyze and evolve ways to reduce the health impacts of impurity water and wastewater disposal mainly by industries in Hlaing TharYar Industrial Zone.

Specific objectives of the study are:

(i) To evaluate the level of awareness of the residents about the costs what they incur for the decline in water quality

(ii) To expose the problems created by the establishment of the Industrial Zone causing declining water quality and health problems

(iii) To analyze the direct and indirect costs on health from declining water quality.

1.8 Scope of the Study

This study has to emphasize on the health costs that are related to declining water quality. Thaung Gyi Lay village and Yay Oakkan village consist of this village group and the industry zone is around this village group. So, this village group has suffered the water pollution problems more severe than the other villages.

1.9 Research Questions

In this study, the selected households will be asked to the following questions on

(1) Awareness of the costs what they incur for the decline in water quality
(2) Treatment of water by boiling or otherwise
(3) Medical cost on different types of health problems
(4) The ways they use to protect the current health problems
(5) The current water supply system provided by the government for this area
(6) Why the respondents did not boil the four water sources for their drinking

2.0 REVIEW OF LITERATURE

Under this health impacts from water pollution research area, water pollution is one of the most widely study topics among researchers. Water pollution is the contamination of water bodies (eg. lakes, rivers, oceans, aquifers and groundwater). Water pollution occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. Water pollution affects plants and organisms living in these bodies of water.

2.1 Water Pollution

Water pollution has continued to increase from time to time for several reasons. Industrial waste, local sewage, pesticides and fertilizers, oil spills and others remain the major causes of water pollution. According to (Chiras, 2006), Water pollution is any physical or chemical change in water that directly affects the organisms. It’s a global problem, the types of pollution differs from one country to the other according to the level of development. For example, in poor and non-industrialized countries, water pollution is mainly caused by human and animal wastes, pathogenic organisms, pesticides, and sediment from improper farming and timber practices. The developed countries also suffer from these same problems, but their more stable lifestyles and numerous industries create an additional chance other hazardous pollutants such as heat, toxic, metals, acids, pesticides, organic chemicals and a collection of pharmaceuticals.

Water pollution can generally be divided into two sources:

1. Point source
2. Non-Point source

Point sources include factories, power plants, mines, oil wells and sewage treatment plants which release huge amount of toxic chemicals into sewers, lakes and rivers, (Chiras, Environmental science, 2006). (Cech, 2003) also defined it as the contamination that occurs through a pipe or other items and their location can be easily identified.

Point source pollution is easy to identify and their impact can be easily evaluated. The main sources of point source pollution are considered to be factories and waste water treatment plants. The increase of population near the manufacturing centers can contribute to large amount discharge of waste. (Cech, 2003)

The non-point sources include farms, forests, lawns and urban streets. Both sources can create a lot of problems (Chiras, 2006). Non-point source pollution is so broad, it is so difficult to identify due to its large quantity into the source. They flow into rivers, lakes and other water bodies through the movement of surface and ground water and also through precipitation from the atmosphere. It is always difficult to identify, regulate and quantify due to such large and general uses it has (Cech, Principles of water resources, 2003).

Industries remain the major cause of water pollution in most countries of regions in the globe. They produce large amount of waste causing pollution of rivers, lakes and other water bodies, which is transported directly into the water source then it causes water pollution.

Water pollution is the result of industrial waste and municipal waste. Industrial waste can be divided into two categories, the organic and inorganic waste. Most of the inorganic waste is mineral and chemical in nature which has added greatly to water pollution problems. The waste that contains metals such as nickel, iron, copper and chromium: salts such as compounds of sodium, calcium and magnesium: acids such as sulphuric and hydrochloric and several other compounds. The inorganic waste originate from pickling, acid mine drainage, metal finishing and plating and from the mining, processing and manufacture of a wide variety of metal and chemical products (Schwartz, 1966). This shows that when the concentration of industries in a region may increase the amount of water pollution, leading to increase in cancer and other water borne diseases due to the presence of chemicals in the water.

The main impact of water pollution is mainly water borne diseases, diarrhea, typhoid, cancer and others which lead to death. Since population depend on water mostly for our survival, water pollution is a threat to our lives. The impact of water pollution is a connected process, for instance if the water is polluted, it will have an impact on the organisms in the water as well as the humans who mostly depends on the organisms as their source of consumption.

3.0 RESEARCH METHODOLOGY

3.1 Study Area

This study was mainly conducted in residential and business areas along the Pan Hlaing River which is the length of 48.06 kilometers. This village group is typical of urban village in developing countries in that they are densely populated. Large numbers of people are poor and work in casual.

This area was selected because they cannot get enough clean water for their daily use, the garbage system is poor, the surrounding environment is unhealthy conditions such as muddy, dirty houses, the living standard is low and they have suffered from the infection diseases caused by wastewater of industries. Figure (3.1) shows the study areas and the study areas and the detailed survey locations are indicated by circles.

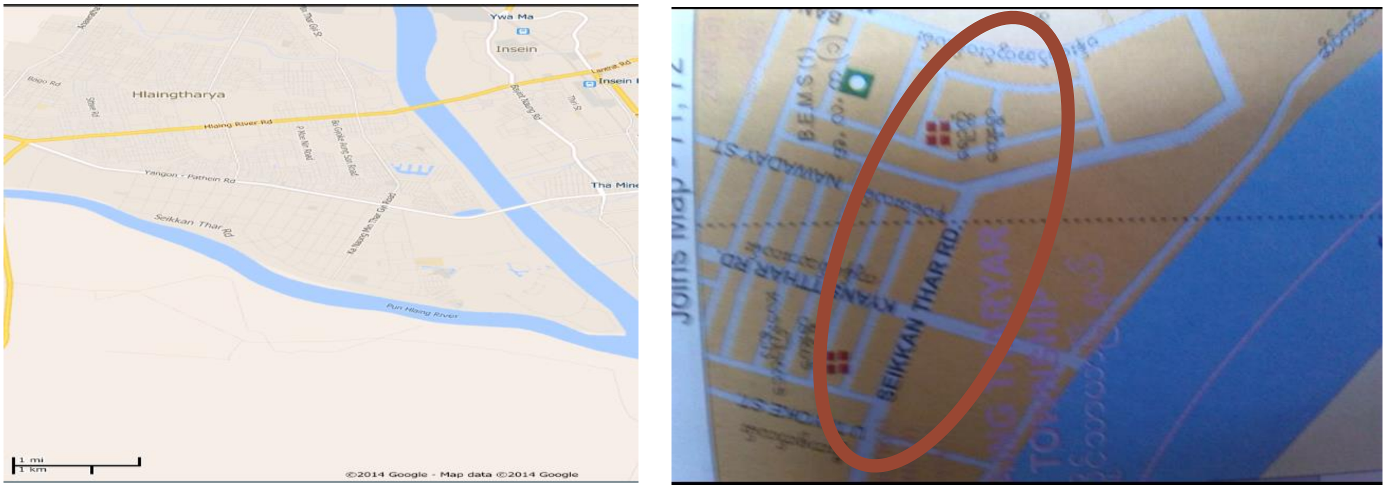


Figure (3.1) Study Area for Research Survey

3.2 Methods of the Study

For the purpose of achieving the research objectives, inferential statistical method was used in this study and systematic sampling method is mainly used for primary data. Primary data on the using types of water of residents will be gathered through the 296 respondents from Yay Oakkan village and Thaung Gyi Lay village, questionnaires from the households. The questionnaire consists of the points for asking may include awareness about the role of purified water, experiences with water shortages and rationing, the amounts paid to water vendors other than the concessionaires. Secondary data will also be gathered from the reports, journals and related government departments.

Sampling Procedure

Systematic sampling method is mainly in this study. Regarding the Determination of sample size (n), since most of the variables in this research are qualitative variables, the required sample size (n) will be computed on the estimation of a population proportion (P) with a desired bound (B) of error on estimation of P. The formula for n is given,

$$n = \frac{Npq}{(N-1)D + pq}$$

Where:	n	=	sample size
	N	=	total number of houses in the area
	p	=	population proportion
	B	=	bound on the error of estimation
	q	=	(1-p)

$$D = \frac{B^2}{4}$$

Where B is 95 %, bound on the error of estimation. Here, in this survey, N= 2829; and p and q, are taken to be 0.50 to allow for the maximum sampling error of the estimate. B is taken to be 0.055=5.5%. Putting the corresponding values of N,p,q,B and D in the above formula, the required sample size (n) turned out to be n. So, the research picks this interval, 6. The members of this sample will be individual 1,11,21,31,41,51,61, ……….., and the estimated number of houses is 296.

3.3 Data Collection Methods

This study consisted of two types of survey: the household survey and water test. In the household's survey, inferential statistical method was used and systematic sampling method was mainly used for primary data. Structured face-to-face interviews were conducted by trained interviewers in order to collect a cross-section data. Secondary data will also be cited from literature and related government departments.

For the water test, the water sample was mainly collected from the tube-well (below 90 feet depth), tube-well (above 400 feet depth), coverless lake water and Joe-phyu pipeline water supported by the government that are situated in Hlaing Thar Yar Industrial Zone in two seasons during the period of March 2015 to August 2015 the covering hot season and rainy season.

3.4 Survey Instruments

For the household's survey, primary data on the using types of water of residents will be gathered through the 296 questionnaires from the households. The household questionnaire covered four areas: Background Informing, Water Quality, Awareness about Water Pollution and Health Habits of the Household.

For the water test, all water were carried 2L of sterilized with prewashed polyethylene containers. They were packed in an ice box and quickly taken them to the laboratories within 6 hours and placed in cool and dark conditions for analytical purposes.

3.5 Expected Results and Dissemination

This study is expected that the villagers can notice the causes of using Tube-well (90 feet) water and it can affect the health of the villagers who use it daily. They also have the knowledge how to protect the water pollution, how they should use the water to be suitable for their health and water pollution occurs caused by the wastewater disposal from the industry and how to avoid occurring the infection diseases.

We are going to disseminate our results to the public in this area as pamphlets and holding the small workshop including the local medical staff, village administrative body and the villagers by collaboration with the local medical department. And then we write an article in some health journals and our university anniversary magazine.

4.0 Results and Discussion

4.1 Household Survey

In this survey, 296 households were interviewed. At (74 %), slightly more women participated in the survey than men. But these women could explain the situation of the water what they have been using daily and answered the questions clearly.

Most respondents come from low- or middle-income households. They lived, on average, 30 minutes away from the industry. Their houses were mostly apartments and narrow spurious. One third of the respondents were migrants from outside of this area but most of them had been living in this area so long. On average, their monthly income was 150000 kyats (USD $ 150) and (120) had monthly incomes below that standard national minimum income, which is USD$ 108. The majority of people in these village groups mostly work in factories in the industrial zone.

4.1.1 Educational Level

Educational levels were directly related to the availability of livelihood options and the decision making process of using the best water types for their family's health. This survey illustrated a mixed picture.

Table 4.1 Educational profiles of respondents

Educational Level	Number of Respondents	%
Primary Education	117	39.5
Middle Education	93	31.4
High Education	48	16.2
Graduate	9	3.0
Monetary Education	10	3.4
Others	19	6.5

Source: Calculated from survey data

4.1.2 Kinds of water and using purposes

Table (4.2) shows the number of households which is using the four types of water: (1) from Lake, (2) Tube-well (90 feet), (3) Joe-phyu and (4) Tube-well (400 feet) in this villages group for drinking, cooking and washing purposes. Majority of the households use more than one type of water daily.

Table 4.2 Kinds of water and using purposes

Using Purposes	Types of Water									
	Purified water		Lake water		Tube-well water (90 feet)		Joe-phyu water		Tube-well water (400 feet)	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%
Drinking	68	23.1	0	0	3	1.0	206	70.1	17	5.8
Cooking	16	5.0	9	2.8	7	2.2	186	57.9	103	32.1
Washing	1	0.3	18	5.0	145	40.3	43	11.9	153	42.5

Source: Calculated form survey data

The households usually use two types of water jointly together for their drinking, cooking and washing. Some households use Joe-phyu water for drinking as well as for cooking. Some households use Joe-phyu water and Tube-well water (400 feet) for cooking. Some households use not only purified water but also Tube-well water (400 feet) for their drinking. In accord with our survey results, drinking water is the most form of Joe-phyu water. As their cooking they use mostly Joe-phyu water and Tube-well water (400 feet). Tube-well (90 feet) and Tube-well (400 feet) are used the most for washing.

4.1.3 Number of Households using Boiled Water and Raw

Table (4.3) shows the number of households using boiled water and not using boiled water. In this survey, two-third of the households know very well to use boiling water for the health of their family but most of them are not used to boiling water.

Table 4.3: Number of households using boiling water and raw

Sr. No.	Types of Households	Number of Households	Percentage (%)
1	Using boiled Water (drinking)	221	74.7
2	Not using boiled water (drinking)	75	25.3

Source: Calculated from survey data

4.1.4 Number of Households Awareness the Water Pollution

Table (4.4) shows the number of households' awareness on water pollution. According to the data collection, most of the respondents are not only low educated person but also they have a little knowledge about water pollution.

Table 4.4: Number of Households awareness on water pollution

Sr. No.	Types of Households	Number of Households	Percentage (%)
1	Awareness of the water pollution	202	68.2
2	Not awareness of the water pollution	94	31.8

Source: Calculated from survey data

4.1.5 Disease profile of survey subjects

Table (4.5) shows the disease suffered from the both respondents and family members. According to this survey, (22) kinds of disease were found.

Table 4.5: Disease profile of survey subjects

Sr. No	Name of Disease	Qty of person who suffered from disease	Sr. No	Name of Disease	Qty of person who suffered from disease
1	Headache	46	12	Hay fever	6
2	Dizziness	38	13	Stomachache	5
3	Fever	32	14	Arthritis	5
4	Diarrhea	20	15	Cramp	4
5	Hypertension	18	16	Diabetes	4
6	Skin problem	12	17	Typhoid	3
7	Heart disease	12	18	Cholera	2
8	Neuritis	9	19	Liver disease	2
9	TB	8	20	Yellow fever	2
10	Asthma	7	21	Epilepsy	2
11	Nausea	6	22	Colic	1

According to our study, there are four kinds of water which the households use in this area and there is no household which use only one. All households have to use at least two or three kinds of water for their daily use. So, it is difficult to separate this information according to the source of water.

But in accord with the water test, (62.6%) of the respondents have to use the Tube-well water (90 feet) for their washing and we found the high value of turbidity, Ammonia-Nitrogen (NH_3N), Cyanide, Alkalinity, iron and chloride mainly in the Tube-well water (90 feet) and the bromine, turbidity, Cyanide and Alkalinity value are also high in the Lake-water (LW).

Higher turbidity levels are associated with higher levels of disease and can cause symptoms such as nausea, cramps, diarrhea and headaches. And also if there is much amount of cyanide contamination in water, the villagers can feel dizzy, skin problems and in the long run they also cause nerve damage or thyroid problems. Excessive levels of iron can damage DNA, protein, lipids and other cellular components and if there is much amount of Bromine can affect seriously the human health.

So, although all diseases are not related to all sources of water, the diseases of dizziness, headache, fever, diarrhea, skin problems, Asthma, nausea, typhoid, cholera and cramp are mostly related to the impurity water, Tube-well water (90 feet) and Lake-water (LW).

4.1.6 Changes of water color (%) (296 respondents)

Table (4.6) shows the comparison of the changes of water color before and after establishing the industrial zone for four water sources answered by the respondents in the survey area.

Table 4.6: Changes of water color (%) (296 respondents)

Type of Water	Unchanged	Changed
Joe-Phyu Water	78.7%	21.3%
Tube-Well Water(90 feet)	24.3%	75.7%
Tube- Well Water	43.2%	56.8%
Lake Water	3.7%	96.3%

Source: Calculated from survey data

4.2 Data Collection Analysis

The regression and correlation analysis was used in our study. Many empirical studies rely quite heavily on these statistical tools. They are perhaps the most commonly used forms of statistical analysis, and are individual when making a large number of business and economic decisions.

4.2.1 Regression Analysis

Regression is a quantitative expression of the basic nature of the relationship between the dependent and independent variables. Regression and correlation analysis recognize that there may be a determinable and quantifiable relationship between two or more variables. That is, one variable depends on another and can be determined by it; or we can say that one variable is a function of another. This can be stated as

$$Y = f(X) \qquad (4.1)$$

Which is read "Y is a function of X", and states that Y depends on X in some manner? Since Y depends on X. It is the dependent variable and X is the independent variable.

Correlation determines the strength of the relationship. That is, while regression describes the basic nature of the relationship between the two variables, correlation measures how story that relationship is. In this study, we used multiple regressions.

Multiple regressions involve two or more independent variables. If Y is said to depend on three independent variables, we can write $Y= f(X_1, X_2, X_3)$. A model containing K independent variables can be expressed as

$$Y= f(X_1, X_2, \text{-------------}, X_k) \qquad (4.2)$$

Or

$$Y=b_0 + b_1 X_1 + b_2X_2 + \text{---------}+ b_k X_k + e \qquad (4.3)$$

Where K is the number of independent variables and b_1 are the coefficients for the variables. e is the random error-component made necessary because not all observations fall directly on the regression line.

4.3 Testing Multiple Regression Coefficients

In this multiple regression coefficients, we test the relation between the diseases by industry, distance from industry and the medical expenses (the sum of medical expenses and income loss per day while feeling the disease) the villagers. We have to test these four water altogether because all respondents use the all kinds of water for their drinking, cooking and washing purposes. So, we assumed that the villagers felt the direct effects of water pollution from these factors.

(1) Hypothesis

$H_0: \beta_1 = \beta_2 = \beta_3 = \text{-------------} = \beta_k = 0$

H_1: At least one is not zero.

$Y= \beta_0 + \beta_1 X_1+ \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4+ \beta_5 X_5+ \beta_6 X_6 + €_i$

$Y= -281.699-463.610X_1+ 1470.924X_2 +156.970X_3 + 837.888X_4-1252.541X_5 +13503.390X_6+ €_i$

Y = Medical Expenses (Medical charges + income loss per day)

X_1 = Lake Water (LW)

X_2 = Tube-Well (90 feet) (TW 90)

X_3 = Joe-Phyu Water (JW)

X_4 = Tube-Well (400 feet) (TW)

X_5 = Distance of Water Sources from Industry

X_6 = Disease Caused by Industry

In this regression analysis, the dependent variable is the sums of medical charges which are the villagers have to pay when they feel illness and all the other independent variables are binary variables. X_1, X_2, X_3 and X_4 are four types of water they are using and if the villagers use them, the value of variable is 1 and if not, the value is zero.

X_5 is the distance of water sources from industry and we have to use the dummy variables 1 and 2. If the source of water they get is near the industry, the value is 1 and if not, the value is 0.

X_6 is the disease caused by the industry and we have also to use the dummy variables and 1 and zero. We asked the villagers "Do you think the disease you surfer from is caused by the industry" for this variable and the answer is 'yes' or 'no'. If it is yes, we put the value of variable, one and if it is no, we put zero.

We applied SPSS>stepwise linear regression approaches to the data to consider which variables are the explanatory variables affecting the change in medical expenses of the sample families. We found that only 3 variables, Tube-well water (90 feet), Distance of water sources from industry and whether the cause of disease is due to industry, are significant. The other sources of water are interrelated and hence the multicolinearity assumption is violated and found to be insignificant.

According to the significant variables, the relationship between the medical expenses (Y) and Tube-well water (90 feet) (X_4) and disease caused by industry (X_6) is positive. But the medical expenses (Y) and the distance of water sources from the industry (X_5) is negative relationship. So, the further the distance from industry, the less they feel the diseases and the less they spend for the medical expenses.

Table 4.7: Relationship between diseases suffered from the residents and four types of water estimate for the targeted area

	Coefficients	Std Error	Sig
Constant	-281.699	1313.747	.830
Lake Water (LW)	-463.610	955.596	.628
Tube-well Water (90feet) (TW 90)	1470.924	459.907	.002
Joe-Phyu Water (JW)	156.970	997.371	.875
Tube-well Water (400 feet) (TW)	837.888	816.438	.306
Distance of water sources from industry	-1252.541	642.257	.052
Disease Caused by industry	13503.390	475.987	.000

Dependent Variable: Total medical expenses, $R^2 = 0.749$, adjusted $R^2 = 0.744$, total n=296

In previous result, we had to entry the data of distance of water sources from industry wrongly. In our questionnaire, we put the six answers which they can choose; (1)under 5 minutes, (2) between 5 and 10 minutes, (3) between 10 and 20 minutes, (4) between 20 and 30 minutes, (5) over 30 minutes and (6) over one hour. So, there are various numbers (1 to 6) in our data entry for that and our result was not exact between the independent variable (X_5) was not dummy variables. Now, we have to divide the distance into two parts. If the distance is under 20 minutes, it is near the industry and if the distance is 20 minutes and over 20 minutes, it is far from the industry. If it is near the industry, the dummy is 1 and if not, 0.

We performed a multiple regression analysis to predict the actual impact from the water in the study area. So, illness occurs caused by the waste water disposal from industry at 100% level of confidence (0.000). And also, there is only Tube-Well Water (90 feet), TW (90) is at 98% level of confidence (0.002) and related to the dependent variable. According to its geographical situation and this water contains iron, calcium and salinity. So, the more tube-well water they use, the more ill they become. According to the interview, almost all households have to use more the tube-well (90 feet) than the other types of water. Turbidity, total dissolved solid (TDS), iron and cyanide values in the tube-well water (90 feet) are high compared with the other types of water and it is higher than the permissible level according to the water test. The results of the experiments for four types of water are shown in Table (4.8),(4.9),(4.10) and (4.11) in detail.

Before 2008, there are (10) tube wells in this village group, (5) can be used for drinking. But after 2008, more factories establish, the more the volume of waste water disposed by various industries. Industries discharge their untreated of only partially treated sewage and industrial wastewater unsystematically into neighboring ditches and on the road. In doing so, they create intense pollution in ditches and rivers.

Besides, before 1997, there were about (2000) people in this village but there are over populated and become urbanization in this area after establishing the Industrial Zone because most of the people in other areas had to migrate for their job opportunities. Being rapid pollution growth and industrialization, not having been well-housing system and not having been proper swage system, drainage system and garbage system, water pollution has been growing. These factors can impact indirectly the water sources in this area because the color, taste and smell of Tube-well water are gradually worse and worse comparing with the situation in 1997.

Nevertheless, turbidity, total dissolved solid (TDS), iron and cyanide values in the Tube-Well water (90 feet) are high compared with the WHO and EPA standard according to the water test. Higher turbidity levels are associated with higher levels of disease causing microorganisms such as viruses, parasites and some bacteria.

Total dissolved solid (TDS) is directly related to the purity of water and quality of water purification systems and affects everything that consumes, lives in, of uses water. According to the answers of respondents, changing the color of JW (90) is (76%) and no change is only (24%). So, the color and smell of tube-well (90 feet) water significantly changes and not suitable for their daily use caused by these factors.

According to the our interview results, almost of the villagers in this area have to use the Tube-well (90 feet) water for their daily use that they can't spend their much money for purified water. Although they know the color, taste and smell of Tube-well (90 feet) water are gradually worse and worse, they have no choice to more use other types of water because the situation of their income and they have no enough knowledge the danger of this water. They always think that their daily small income can be provided for their daily costs. According our water test, turbidity, total dissolved solid (TDS), iron and cyanide values in this water are high compared with the WHO and EPA Standard.

So, if the villagers use this type of water for so long, they can suffer symptom such as nausea, cramps, diarrhea, and associated headaches caused by high level of turbidity. They can also feel not only dizzy, skin problems and in the long run also nerve damage or thyroid problems due to the cyanide but also damage DNA, proteins, lipids and other cellular components caused by excessive levels of iron.

Distance means the distance of water sources they get and the industry. According to our regression analysis, distance from the industry is significant but the coefficient sign is negative. So, we assumed that there is negatively relationship between the distance from industry and the cost of illness. The nearer the water sources they use from the industry, the more ill they suffer and the higher the health cost. The greater the distance, the less ill they suffer and the lower the health cost. This makes sense since it implies that water taken from a location further away from the point source is less polluted.

4.4 One-way Anova Test

Medical expenses are classified into two groups between those who boil water and those who don't and one-way anova test is used for these factors. In this test, we wish to determine whether the difference between mans for the two sets of scores is significant.

Hypothesis:

$H_0: \mu_1 = \mu_2$

$H_1: \mu_1 \neq \mu_2$

Decision Rules

If $F > k$, reject H_0

Otherwise accept H_1

In this experiments, the F-value is not significant ($p>0.05$) and therefore it can be stated thet there is not significant improvement when $F(194) = 1.145$, $p> 0.05$ and see that $F = 1.145< k = 5.02$. We accept the null hypothesis and reject the alternative hypothesis that the variances are equal. That is, there are no significant differences in health cost between those who boil water and those who don't.

4.5 Community Perceptions of Health Profile

In an open question on predominant health problems in the community, the respondents mentioned that skin problems, diarrhea, illness, headache, dizziness were the most common health problems amongst the population in this area. In addition, people also suffer from hypertension, asthma, TB, neuritis, hay fever, arthritis, stomachache, hearth disease, nausea, cramp, cholera, epilepsy, yellow fever, colic, liver disease, diabetes and typhoid.

Headache and dizziness were widespread in the study area. Almost all participants of interview claimed to have experienced headache and dizziness because of their frequent contact with water and some participants were currently suffering from dizziness because the water they use daily includes the high level of turbidity and cyanide. The people suffer from diarrhea, hypertension and skin problem are a little high in this study. Diarrhea is one of the most prevalent health problems reported to be suffered by children as well as some adults. The source of the problem is the place where they live is unhealthy environments and contact with the chemicals used in the factories.

The majority of the respondents also blamed the lack of proper sanitation system, drainage system and sewage system and lack of knowledge about hygiene for diarrhea, skin problem, TB, frequently illness which are frequent among children, slum dwellers and factory workers.

Currently, 62.6 percent of the villagers and 32.4 percent of villagers were found to be using tube-well (90 feet) and tube-well (400 feet) water for washing and day-to-day household activities. Culturally open water bodies have been the most common source of water for bathing. People generally bathe at least once a day.

4.6 Water Quality Analysis

4.6.1 Physicochemical parameters of Water Samples

Results of the experiments are presented in above table. It shows the quality parameters of the untreated water samples collected from four sampling sites in Industrial Zone and their disposal channels.

Table 4.8: Some Physiochemical Parameters of Water Sample Collected from Industrial Zone (in Hot and Rainy Season)

Parameter	Unit	Hot Season				Rainy Season				WHO std*	EPA std**
		S_I	S_{II}	S_{III}	S_{IV}	S_I	S_{II}	S_{III}	S_{IV}		
pH	-	7.95	7.06	7.32	7.42	7.08	6.52	7.61	7.15	**6.5 ~8.5**	**6.5 ~8.5**
Bromine	ppm	1.19	0.82	0.01	0.02	0.22	0.85	0.05	0.17	**1**	**-**
Turbidity	NTU	61	174	4.69	3.88	26	44	3	2	**5**	**-**
TDS	mg/L	230	380	40	45	1395	7800	139	859	**500**	**500**
Ammonia Nitrogen (NH_3N)	mg/L	0.09	0.4	0.2	0.1	0.06	0.06	0.03	0.01	**0.5**	**0.5**
Nitrite Nitrogen	mg/L	0.06	0.04	0.02	0.02	0.03	0.03	0.02	0.01	**1.0**	**1.0**

(NO_3-N)											
Cyanide	mg/L	9	6	0	1	<0.1	<0.1	<0.1	<0.1	**0.07**	**-**
Alkalinity	mg/L	169	190	30	31	110	200	50	190	**500**	**30 ~ 150**
Hardness	mg/L	90	70	32	45	542	1880	104	246	**500**	**90 ~ 100**
Chloride	mg/L	0.32	0.37	0.01	0.02	640	4125	60	380	**250**	**-**

Sources: (1) Laboratory of Small Scale Industries Department

(2) Water and Soil Examination Laboratory, Department of Fisheries

* World Health Organization Standard for drinking water (2006)

** Environmental Protection Agency for domestic water (2003)

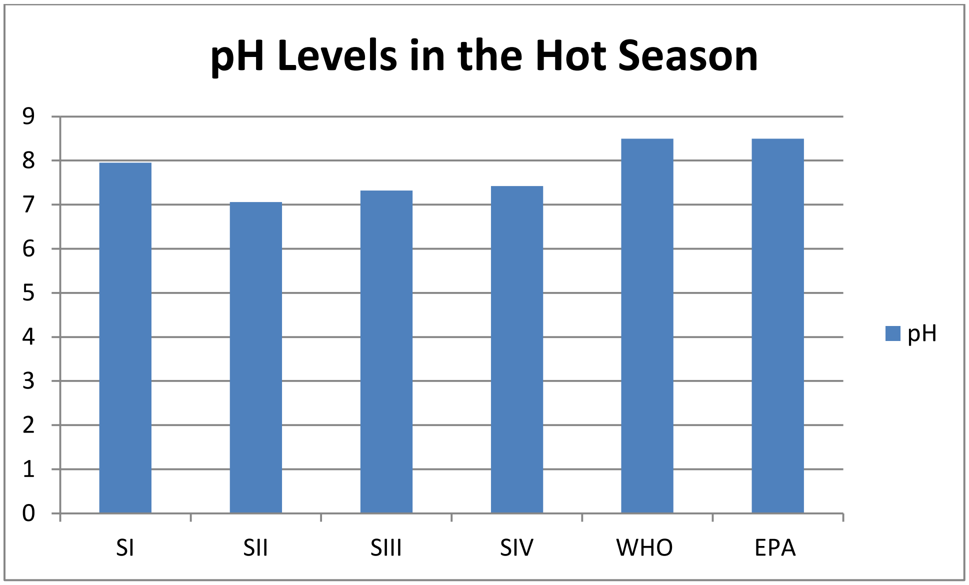
ND = not detectable
S_I = Coverless Lake Water
S_{II} = Tube-well (below 90 feet depth)
S_{III} = Joe Phyu Pipe Water
S_{IV} = Tube-well (above 400 feet depth)
TDS = Total Dissolved Solid

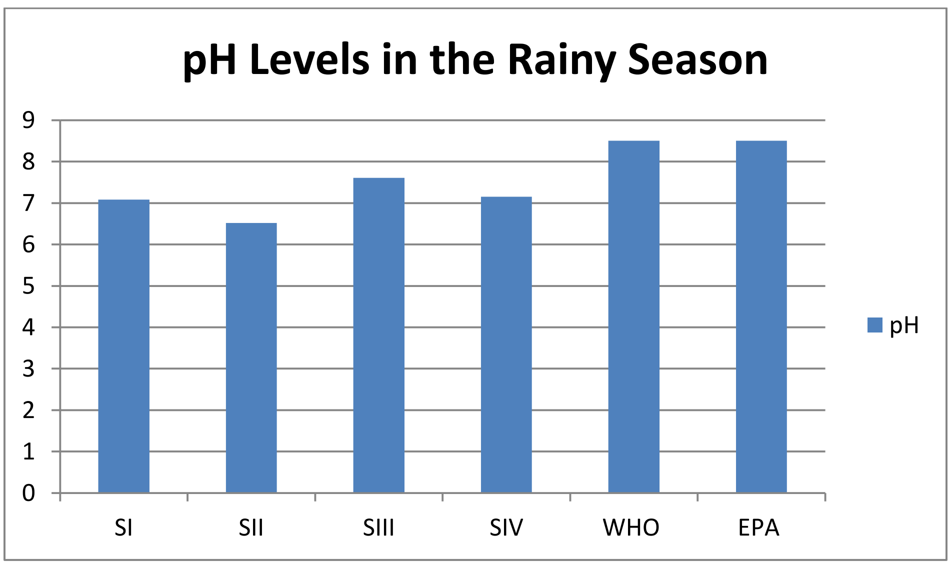
4.6.1.1 pH of water samples

The pH of water varies with the geological nature of the source and the properties of the dissolved solids.

In this study ,the measured pH values for sampling sites I to IV were (7.95, 7.06, 7.32, 7.42) in hot season and (7.08, 6.52, 7.61 and 7.15) in the rainy season. They are described in above table. According to these results, the PH level of Lake water (S I) and Tube-well water (90 feet) (S_{II}) decreased in the rainy season. By comparison with these standard and measured results, the water samples from the industrial zone were harmless for the human even used for drinking on the point of view of permissible level (6.5 to 8.5) of WHO and EPA standard.

Figure 4.1: pH samples of water



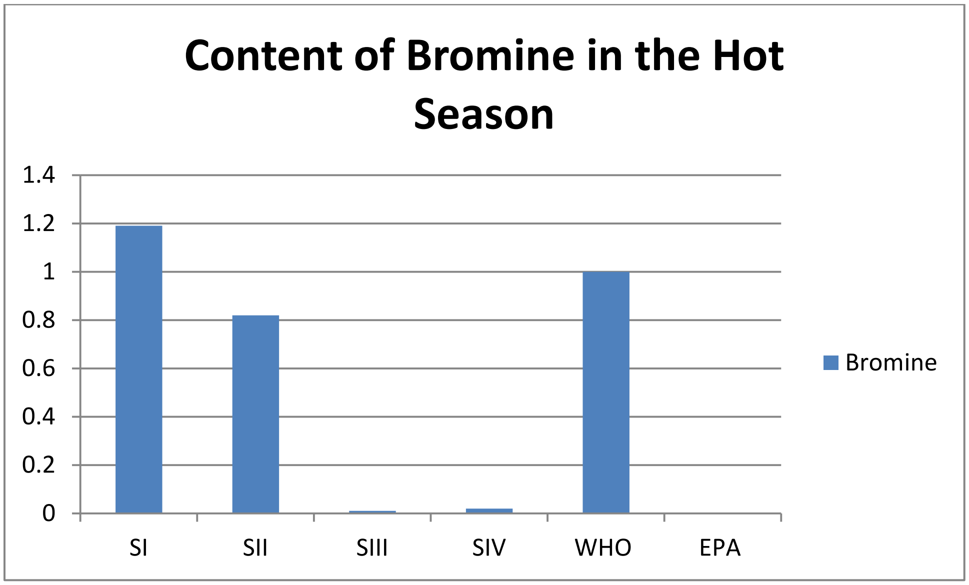


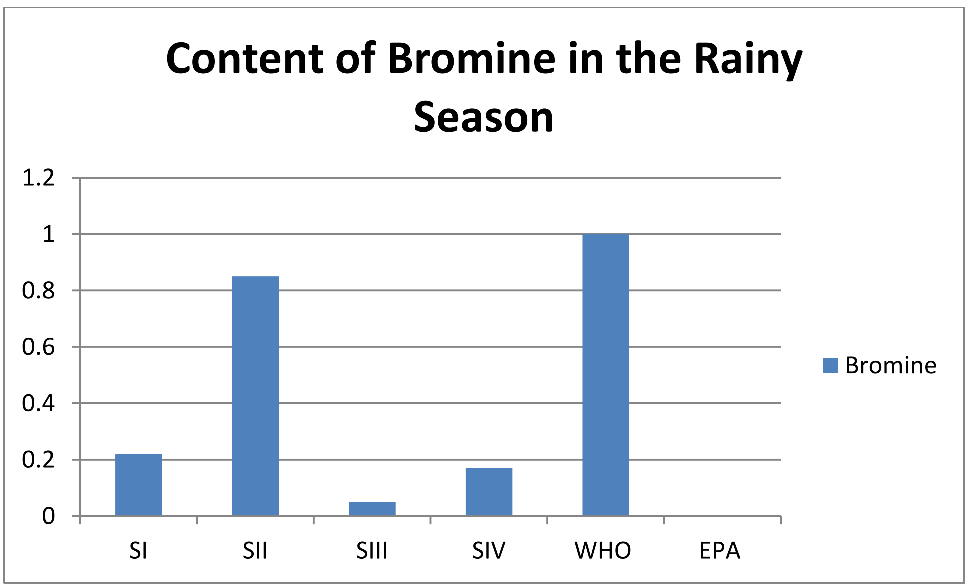
Source: Water Test Result from Laboratory

4.6.1.2 Bromine of water samples

According to the testing, the value of bromine in Lake water (SI) had (1.19) in the hot season and a little higher compared to WHO Standard value (1). The value of other three water samples could accept both in the hot season and the rainy season. If there was higher value of bromine in the water, it can cause serious human health and the environment.

Figure 4.2: Bromine of water samples





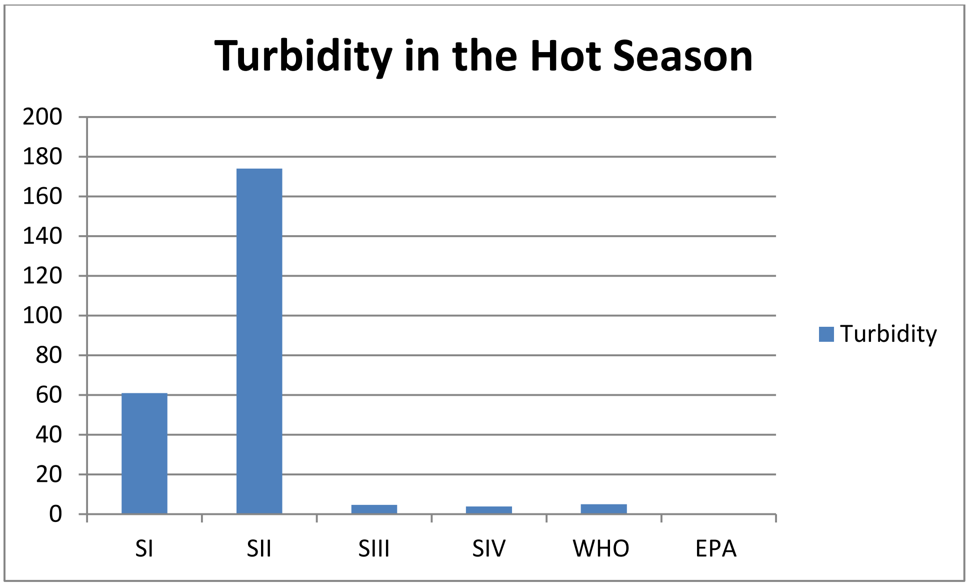
Source: Water Test Result from Laboratory

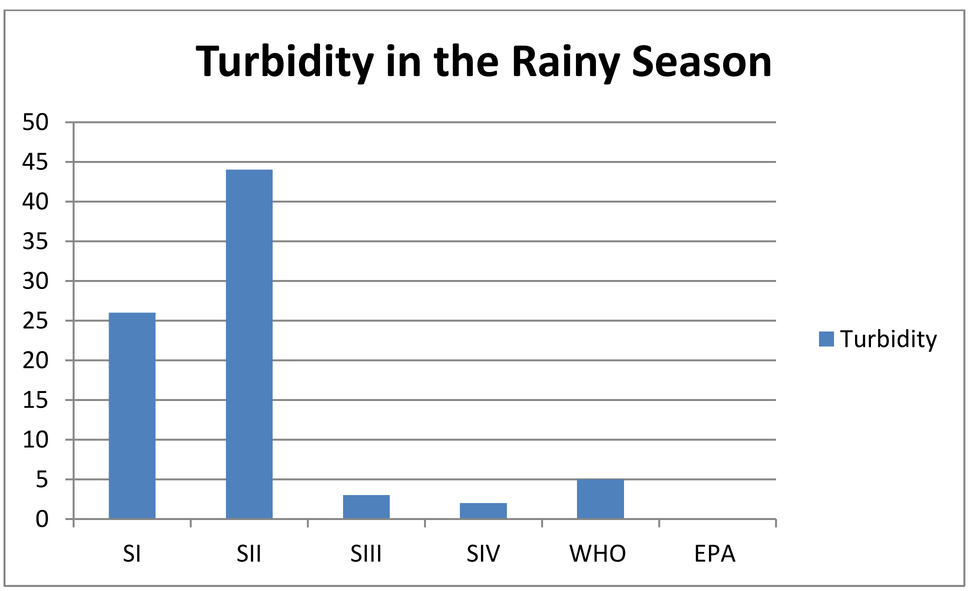
4.6.1.3 Turbidity of water samples

The results of turbidity for all sampling sites are shown in above table during the hot season and the rainy season. In the hot season, SII (Tube-well water (90)) had the highest turbidity value (174) in the rainy season; it decreased to (44). And also the amount of turbidity in Lake water (SI) decreased from (61) in the hot season to (26) in the rainy season.

According to the WHO Standard, value (5NTU), the tube-well (400) (SIV) and Joe-phyu pipe line water were suitable for drinking purpose but the other water samples were not suitable for drinking purpose. The amount of turbidity of these two samples (SI and SII) was higher in the hot season. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organizations can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.

Figure 4.3: Turbidity of water samples



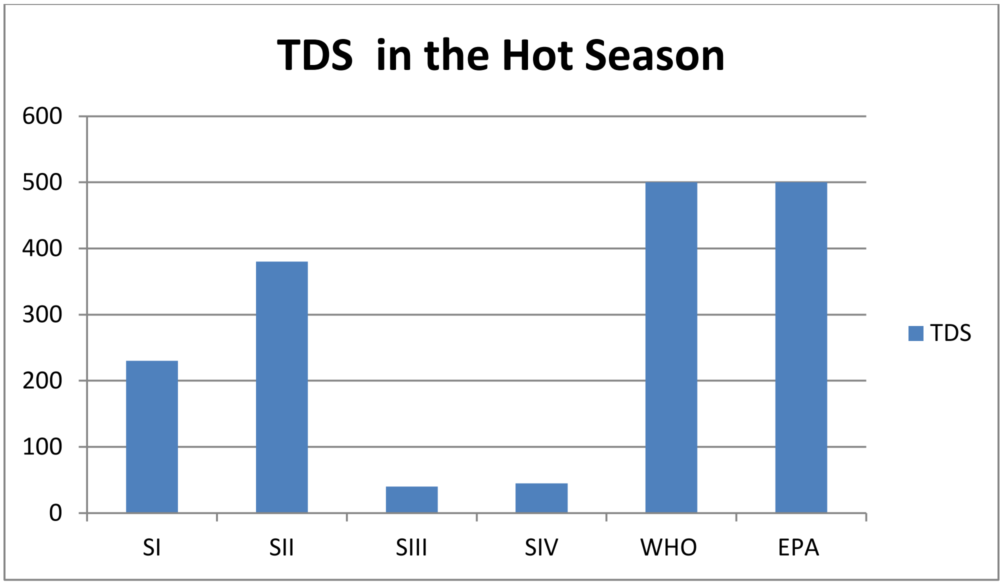


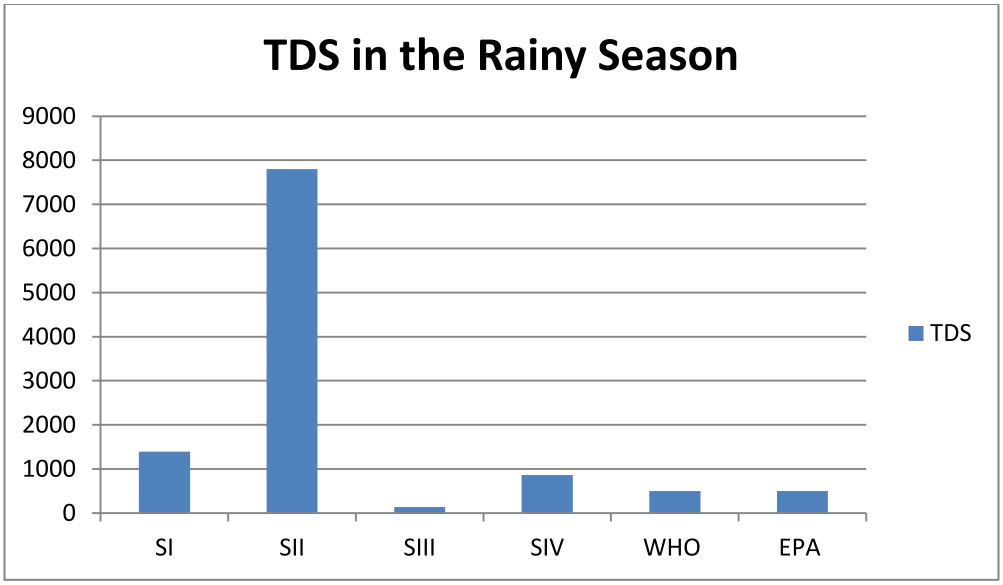
Source: Water Test Result from Laboratory

4.6.1.4 Total Dissolved Solid (TDS) of water samples

In accordance with the experiments, the TDS values of all samples during the hot seasons were less than the literature value of 500 mg/l (WHO, 2006 and EPA, 2003). But in the rainy season, the values of all samples were extremely high. TDS is directly related to the purity of water and quality of water purification systems and affects everything that consumes, lives in, or uses water.

Figure 4.4: Total Dissolved Solid (TDS) of water samples



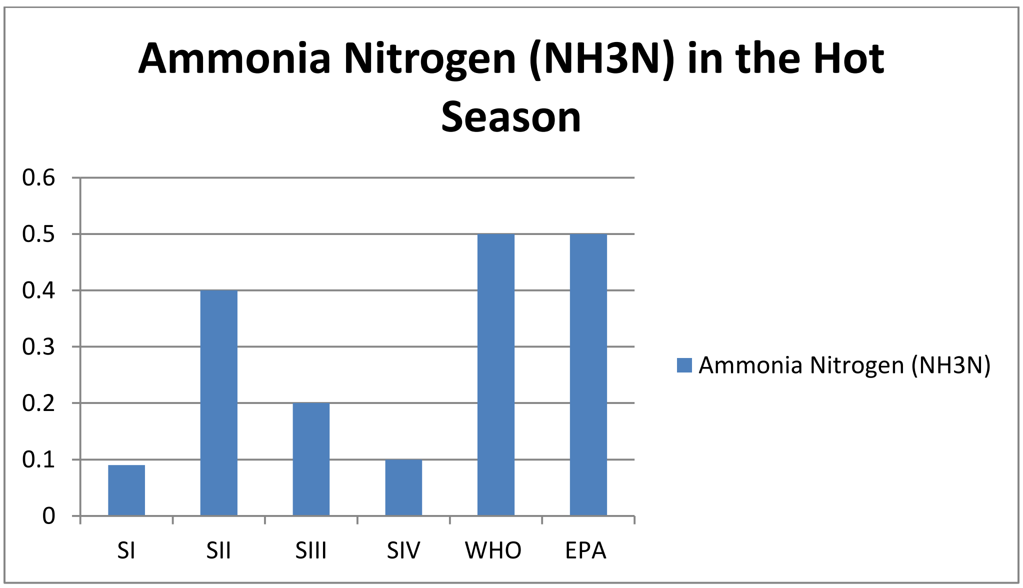


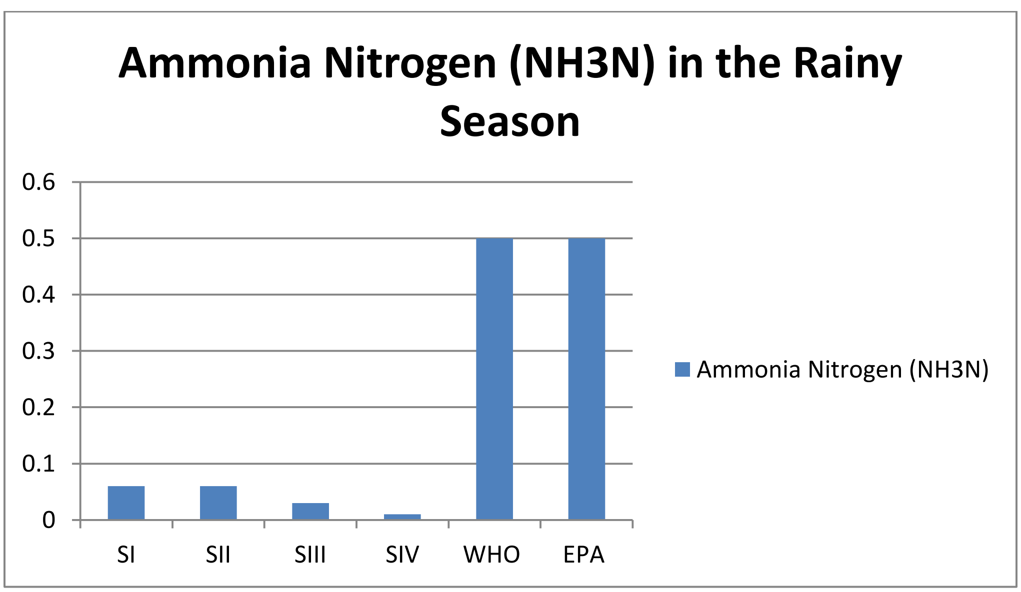
Source: Water Test Result from Laboratory

4.6.1.5 Ammonia-Nitrogen (NH_3N) of water samples

In this study, the connections of ammonia nitrogen were found to be the lowest value of (0.1) ppm for the tube well (400) and the highest value of (0.4) ppm for the water sample $S_{II,}$ tube-well (90 feet depth) in the hot season but the value of all samples were less than in the rainy season compared with the hot season. Due to the study, the water sample from S_{II}, tube-well (90 feet depth) water is near the WHO and EPA Standard (0.5) ppm in the hot season. So, this water is not suitable for drinking in the hot season.

Figure 4.5: Ammonia-Nitrogen (NH_3N) of water samples



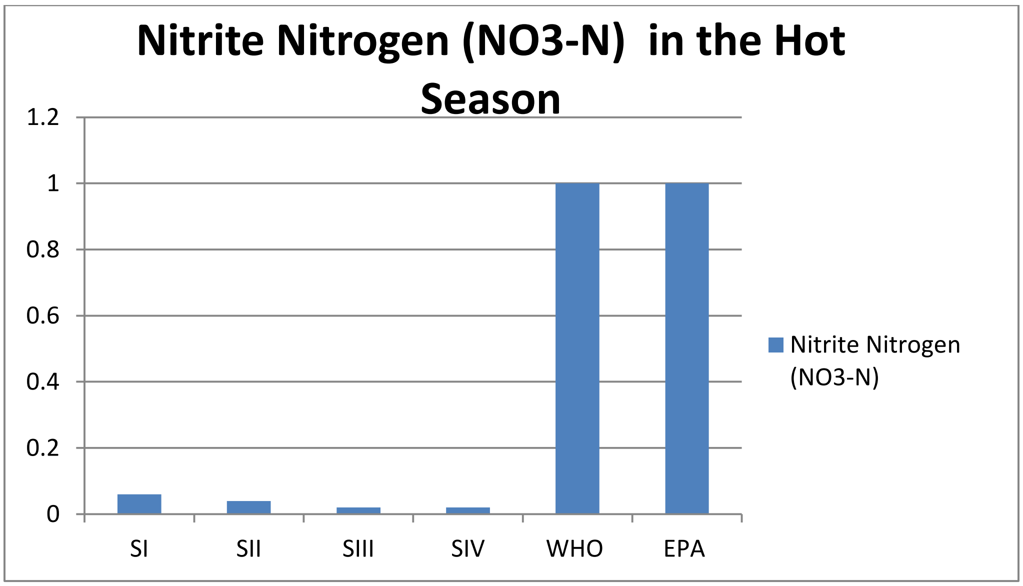


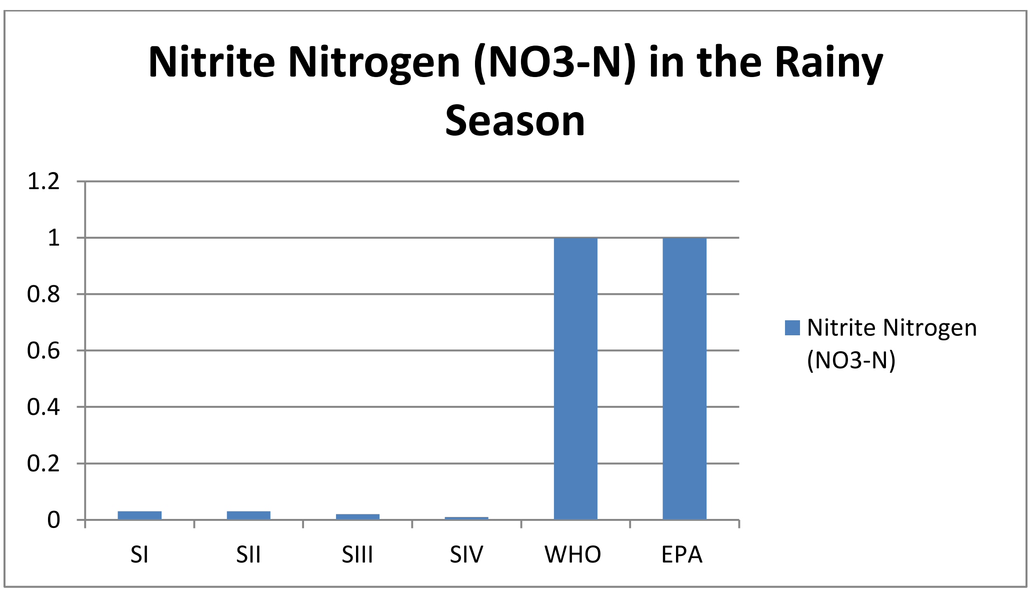
Source: Water Test Result from Laboratory

4.6.1.6 Nitrate Nitrogen of Water Samples

In the above table, the nitrate nitrogen concentrations of water samples were found to be in the range (0.02) to (0.06) mg/l in the hot season and (0.01) to (0.03) mg/l in the rainy season. The WHO guideline for drinking water and EPA Standard for domestic water is (1.0) mg/l. This implies that all the samples were suitable for drinking water and for domestic purposes. If the nitrate content of water exceeds the above limit, the public should be warned of the potential dangers of using the water.

Figure 4.6: Nitrate Nitrogen of Water Samples





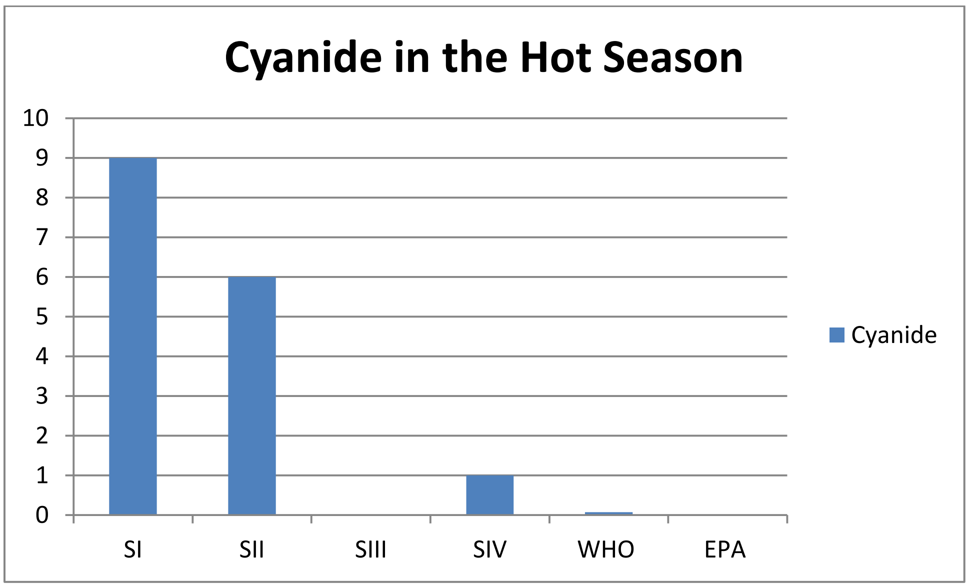
Source: Water Test Result from Laboratory

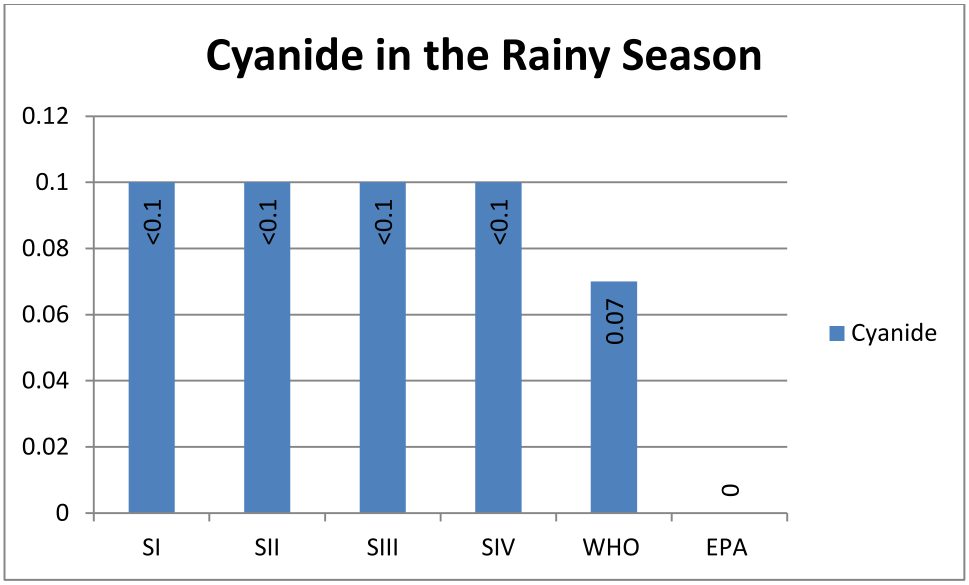
4.6.1.7 Cyanide of Water Samples

Cyanide contamination in the water discharges from steel metal factories, the plastic and fertilizer factories. The contents of cyanide in four collected water samples were in the range of 0 to 9 mg/l in the hot season. According to the WHO standard value of 0.07, the contamination of cyanide in all water samples was high except the S_{III} (Joe-phyu pipe line water).

Nevertheless, the contamination in all water samples were (0.1) mg/l in the rainy season. Although this situation was not as serious as the hot season, this amount can affect the human health. If there is much amount of cyanide contamination in water, people may suffer dizziness, skin problems and in the long run they also cause nerve damage or thyroid problems.

Figure 4.7: Cyanide of Water Samples





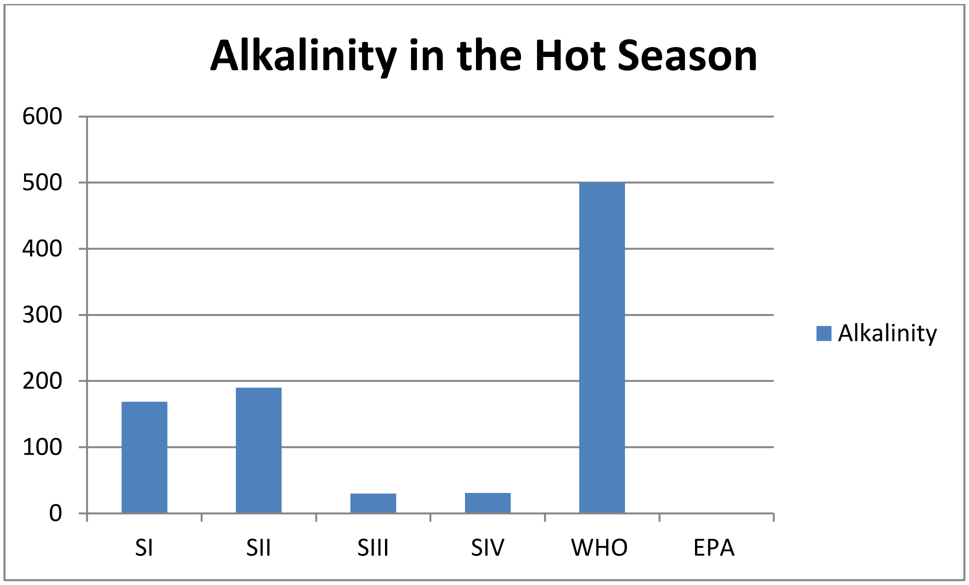
Source: Water Test Result from Laboratory

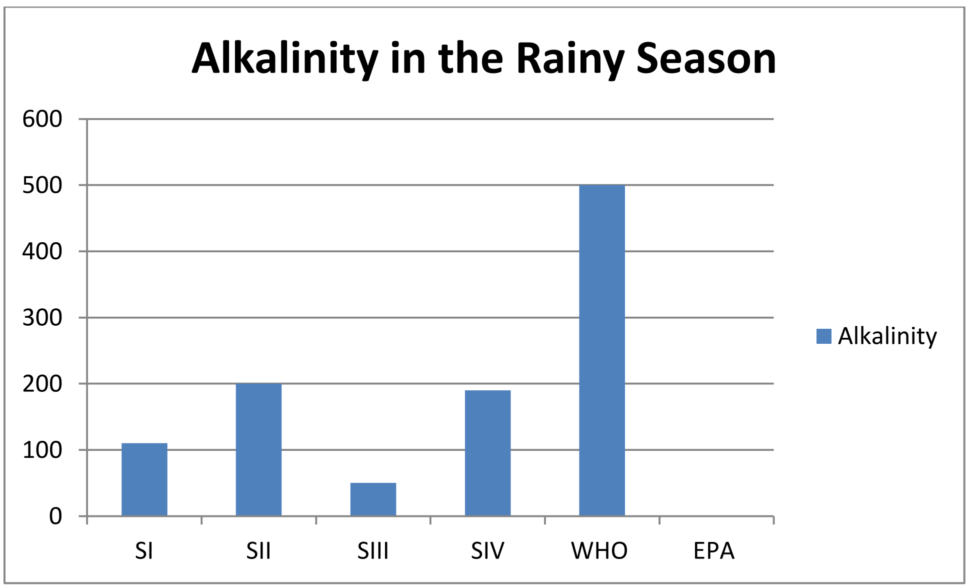
4.6.1.8 Alkalinity of water samples

In the present study, the total alkalinities of the water samples were found to be in the range of 30 to 190 mg/l in the hot season. This is shown in the above table. According to the WHO Standard value of 500 mg/l, all water samples were suitable for drinking but according to the EPA Standard value of 30-150 mg/l, the sample water S_I (lake water) and S_{II} (tube-well 90 feet depth) are not suitable for domestic use.

In the rainy season, S_{II} (tube-well (90) feet depth) and S_{IV} (tube-well (400) feet depth) had much amount of alkalinities than in the hot season and according to the EPA Standard, they are not suitable for domestic use.

Figure 4.8: Alkalinity of water samples





Source: Water Test Result from Laboratory

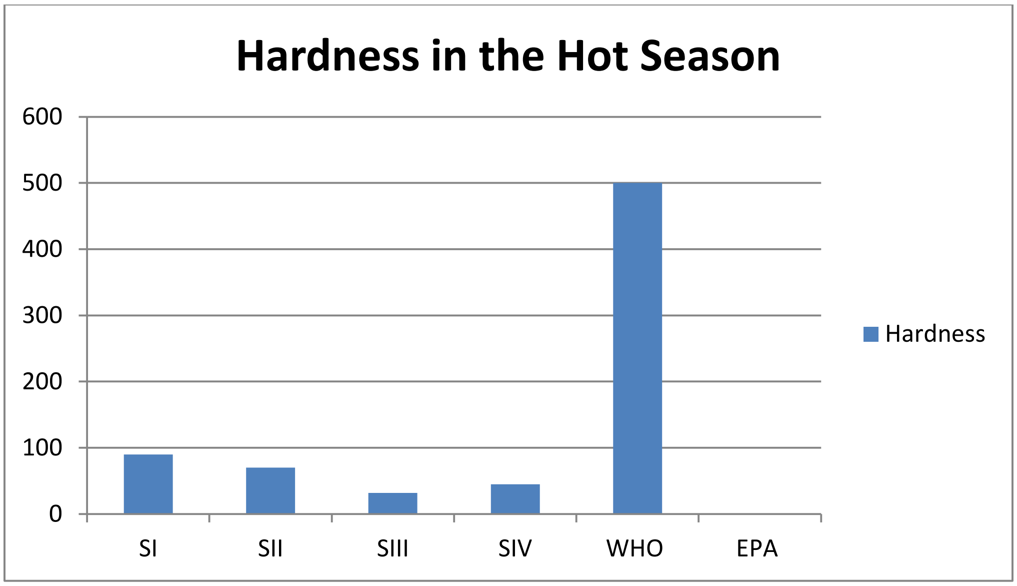
4.6.1.9 Total Hardness of water samples

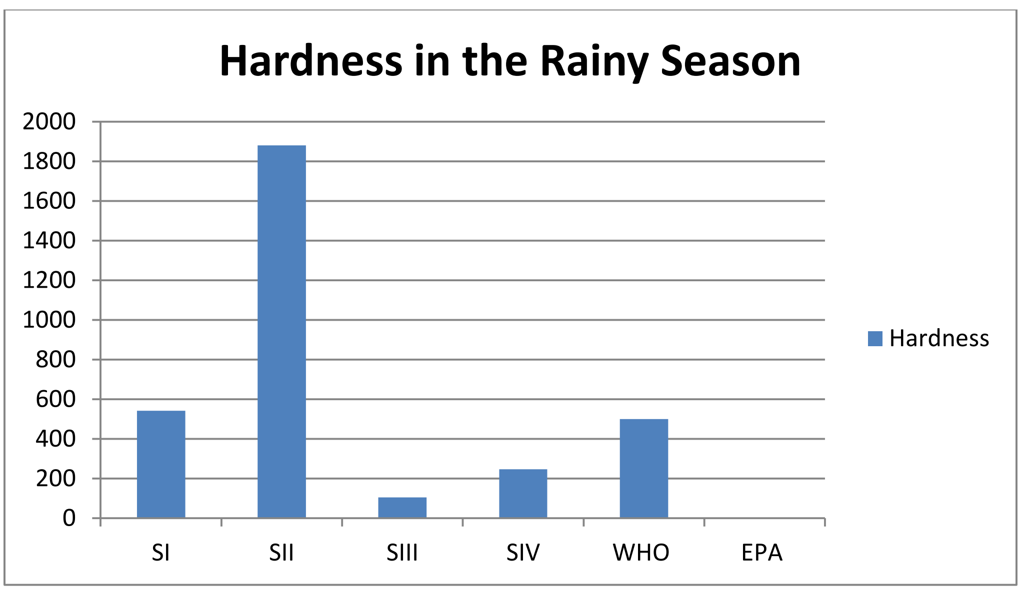
In this study, the total hardness of the water samples were found to be in the range of 32 to 90 mg/l. S I (lake water) possessed the highest value of total hardness in the hot season. In literature value, the water with total hardness content of 0 to 17 mg/l are soft and the water with total hardness content of 17 to 60 mg/l are slightly hard, 60 to 120 mg/l are moderately hard, 120 to 180 mg/l are hard water and > 180 mg/l is very hard water (Hooda and Kaur, 1999).

According to the EPA Standard value of 90 to 100 mg/l, S_I (lake water) and S_{II} (tube-well 90 feet depth) are moderately hard for domestic use.

But the results in the rainy season, all types of water samples had the higher level of hardness than in the hot season. According to the both WHO and EPA Standard value of (500) and (90~100), SI (Lake water), SII (tube-well (90) feet depth) and SIV (tube-well (400) feet depth) are very hard water and SIII (Joe-phyu water) is moderately hard.

Figure 4.9: Total Hardness of water samples





Source: Water Test Result from Laboratory

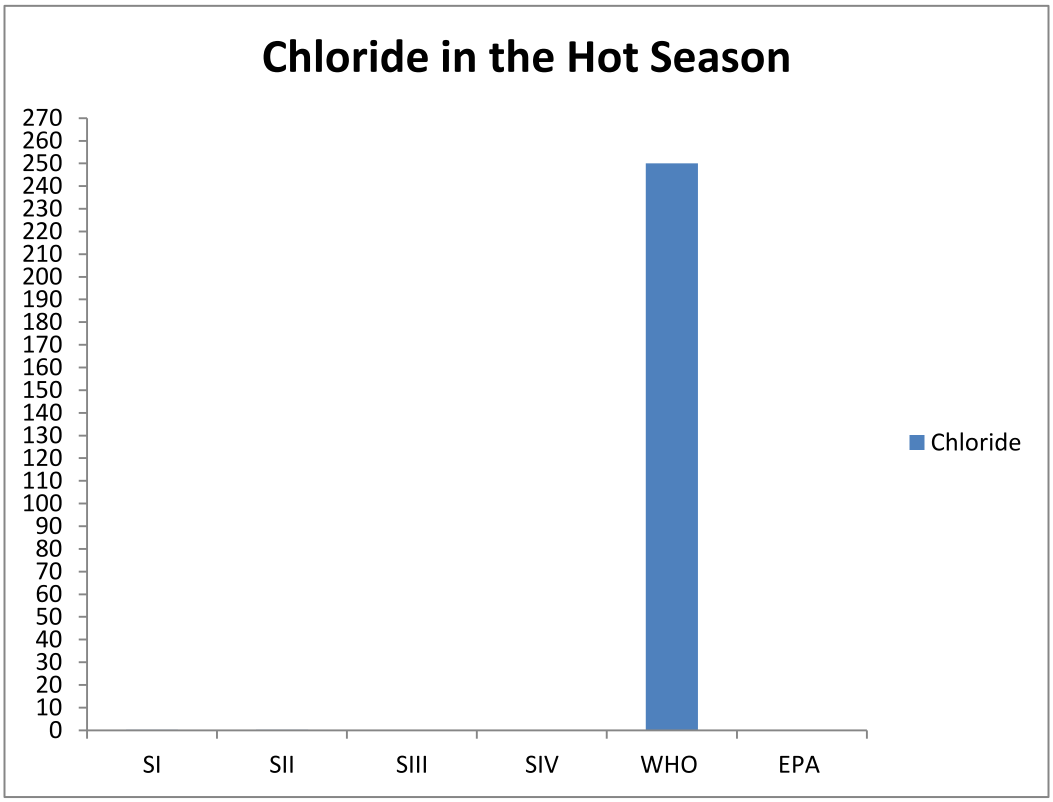
4.6.1.10 Chloride of water samples

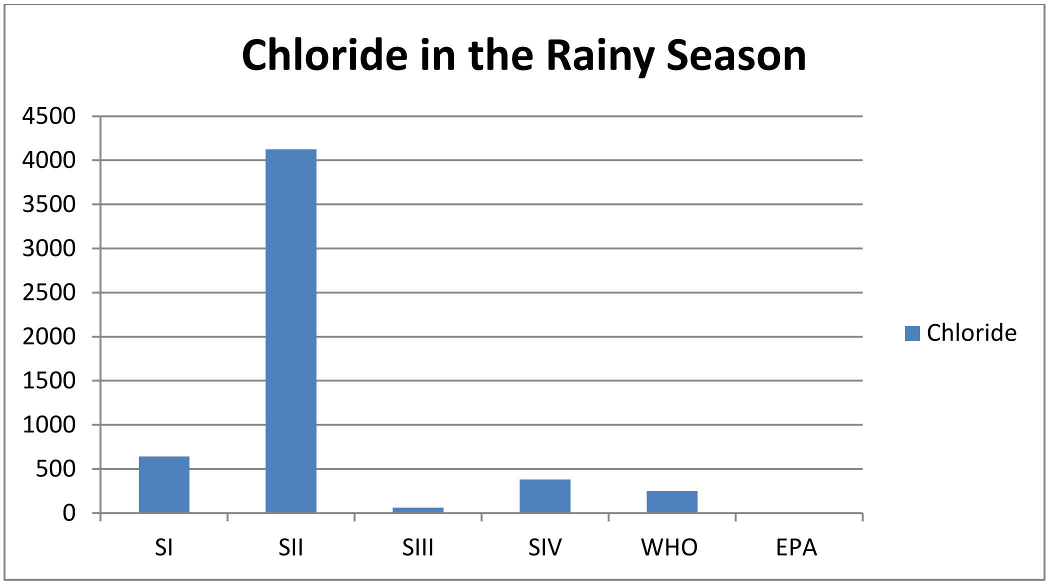
Chloride is completely soluble and very mobile. The accumulation and persistence of Chloride poses a risk to water quality and plants, animals, and humans who depend upon it.

According to this study, the level of chloride contaminant was 0.01 to 0.37 in the hot season and all are lower than the WHO standard value is 250 mg/l.

But in the rainy season, the level of Chloride contaminant in all water samples were higher than the WHO Standard except SIII (Joe-phyu water) and SII (tube-well (90) feet depth) is extremely high to 4125 mg/l although chloride levels can exceed 800 mg/l in this season.

Figure 4.10: Chloride of water samples





Source: Water Test Result from Laboratory

4.6.2 Some Organic Pollutants Parameters of Water Samples Collected from Industrial Zone

Results of the experiments are presented in above table. It shows the organic pollutants parameters of the untreated water samples collected from four sampling sites in Industrial Zone and their disposal channels.

Table 4.9: Some Organic Pollutants Parameters of Water Samples Collected from Industrial Zone (Hot and Rainy Season)

Para meter	Unit	Hot Season				Rainy Season				WHO Std *	EPA Std**
		SI	SII	SIII	SIV	SI	SII	SIII	SIV		
COD	mg/L	29.4	8	20.6	22.6	27.6	31.6	30.2	32.6	**10**	**5**
DO	mg/L	5.0	4.75	7.0	6.0	3	1	2	3	**-**	**4~6**
BOD	mg/L	0.5	1.0	1.5	1.0	2	5	3	4	**6**	**5**

Sources: (1) Laboratory of Small Scale Industries Department

(2) Water and Soil Examination Laboratory, Department of Fisheries

* World Health Organization Standard for drinking water (2006)

** Environmental Protection Agency for domestic Water (2003)

COD = Chemical Oxygen Demand

DO = Dissolved Oxygen

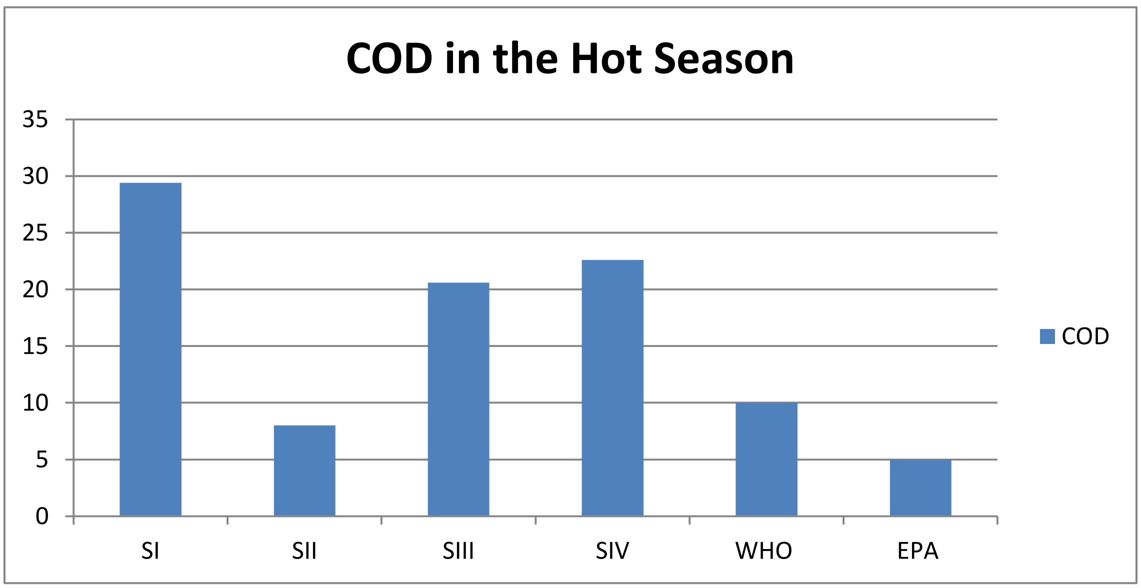
BOD = Biochemical Oxygen Demand

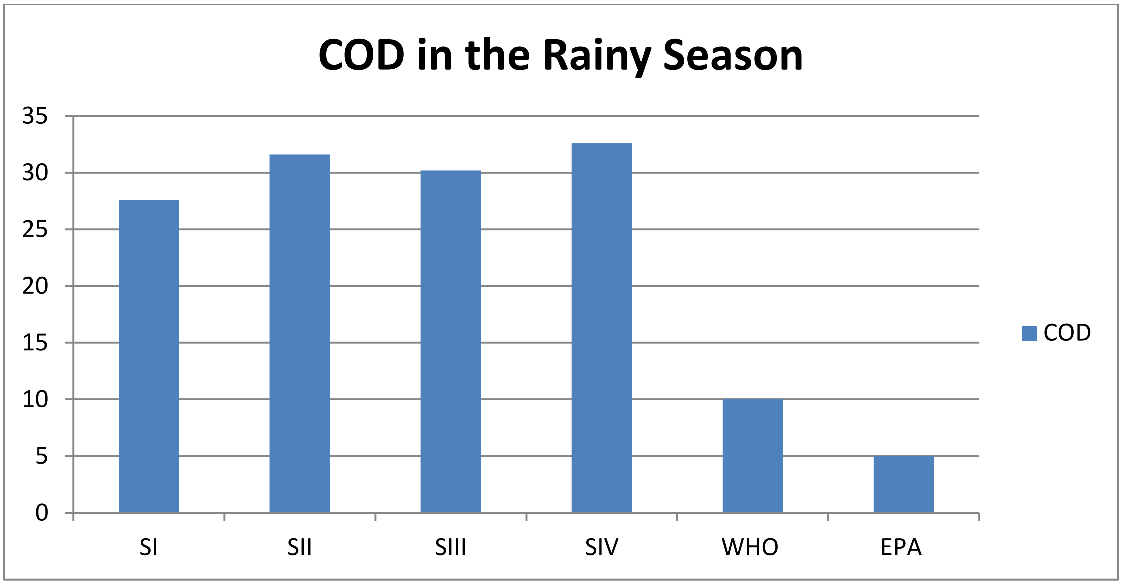
4.6.2.1 Chemical Oxygen Demand of Water Samples (COD)

Many governments impose strict regulations regarding maximum chemical oxygen demand allowed in waste water before they can be returned to the environment. In environment chemistry, the COD test is commonly used to indirectly measure the amount of organic compounds in water and water quality.

In the present study, COD values were found to be in the range of 8 to 29.4 mg/l in the hot season and 27.6 to 32.6 mg/l in the rainy season. The amount of COD in the rainy season is higher than the hot season. This is illustrated in the above table. According to these results, the COD values of water samples in both seasons were higher than the standard values of WHO (10 mg/l) and EPA (5 mg/l). Including high level of COD in the water, chemical disposing from the industry interacts with oxygen and can reduce the water quality.

Figure 4.11Chemical Oxygen Demand of Water Samples (COD)





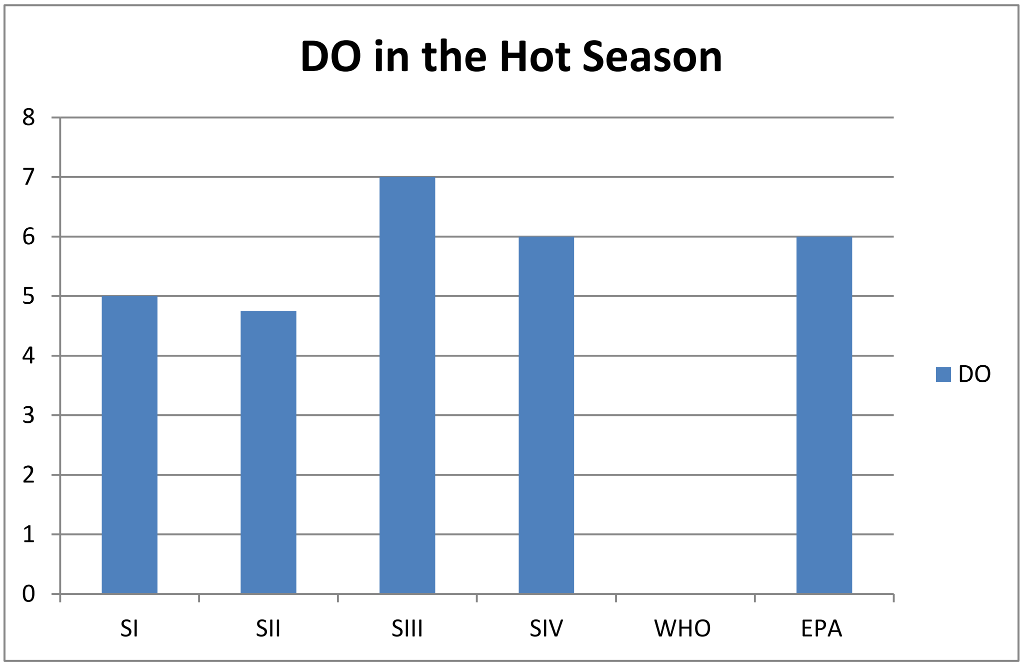
Source: Water Test Result from Laboratory

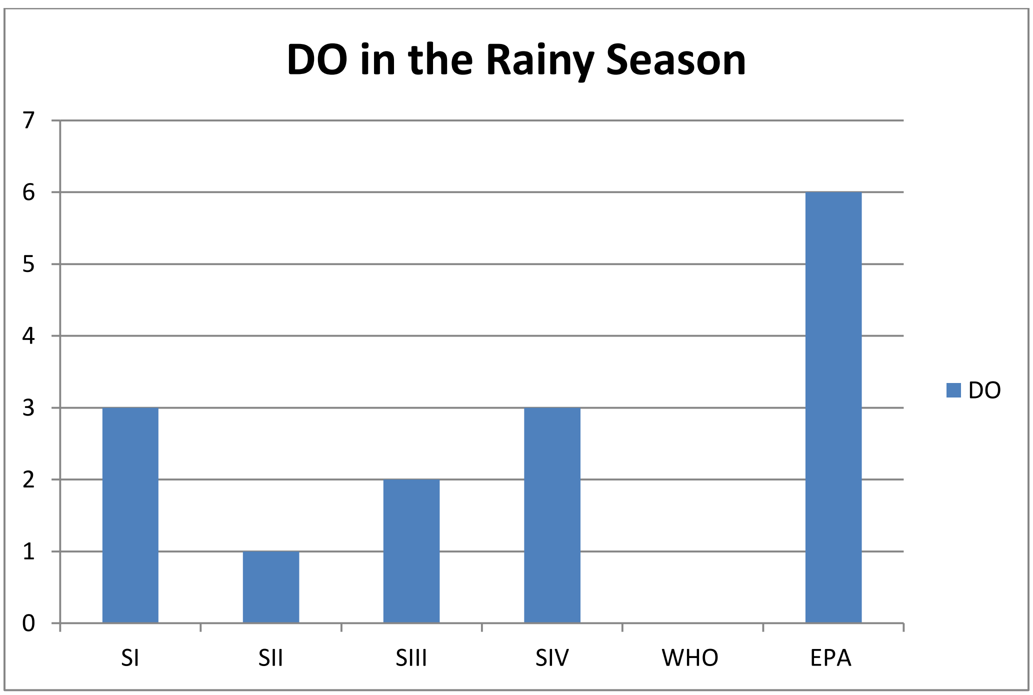
4.6.2.2 Dissolved Oxygen of Water Samples (DO)

In the present study, the DO values of all sampling sites in the hot season 4.75 mg/l to 7 mg/l in the hot season. All results are shown in the above table. In accordance with these data, the DO levels of water sample S_{III} (Joe Phyu water) possessed the highest oxygen level. According to the EPA standard value of 4~6 mg/l, all water samples are good condition.

But the DO amount all water samples sharply went down to be in the range of 1 to 3 mg/l in the rainy season. This is because DO concentrations can change with the seasons, as well as daily, as the temperature of the water changes. At very high altitudes, the low atmospheric pressure means dissolved oxygen concentrations are lower.

Figure 4.12: Dissolved Oxygen of Water Samples (DO)



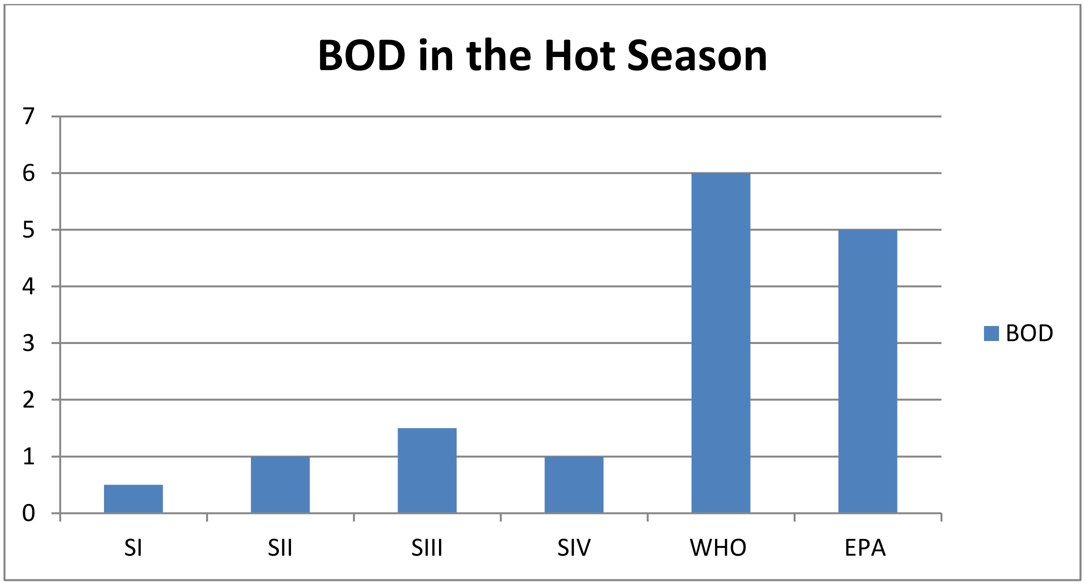


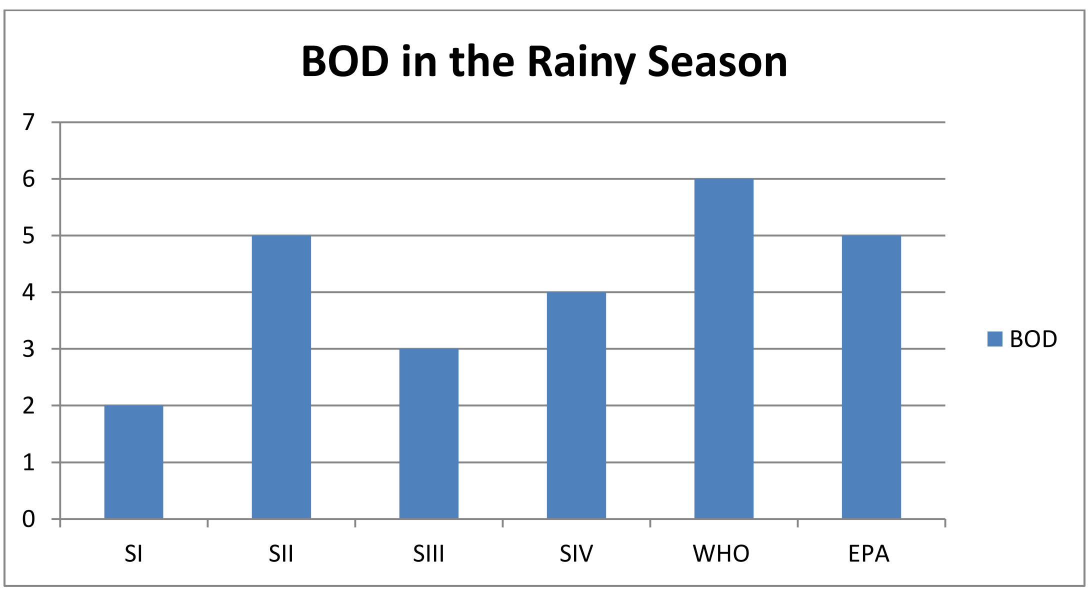
Source: Water Test Result from Laboratory

4.6.2.3 Biochemical Oxygen Demand (BOD)

In this study, BOD values were found to be very lower for the four samples water in the range of 0.5 to 1.5 mg/l in the hot season shown in the above table compound with the WHO standard value of 6 and EPA standard value of 5. Although the value of all samples rises in the rainy season, they are lower than the WHO and EPA Standard.

Figure 4.13: Biochemical Oxygen Demand (BOD) of Water Sample





Source: Water Test Result from Laboratory

4.6.3 Heavy Metals of Water Samples Collected from Industrial Zone

Results of the experiments are presented in the above table. It shows the organic pollutants parameters of the untreated water samples collected from four sampling sites in Industrial Zone and their disposal channels.

Table 4.10: Heavy Metals of Water Samples Collected from Industrial Zone (in the Hot and Rainy Season)

Para meter	Unit	Hot Season				Rainy Season					
		SI	SII	SIII	SIV	SI	SII	SIII	SIV	WHO Std *	EPA Std**
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	**0.01**	**0.05**
Iron	mg/L	1.71	12.58	ND	0.063	0.09	0.24	0.07	0.10	**0.30**	**0.30**
Cadmiu m	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	**0.003**	**0.01**
Copper	mg/L	0.006	0.005	0.002	0.002	ND	ND	ND	ND	**2.00**	**1.00**
Total Mercury	Hg	0.0064	0.0015	0.0041	0.0007	ND	0.0002	0.0001	0.001 5	**0.001**	**-**
Arsenic	ppm	0.0021	0.005	0.0009	0.0067	0.00 20	0.0006	0.0016	0.003 4	**0.01**	**-**

Sources: (1) Laboratory of Small-Scale Industries Department

(1) Water and Soil Examination Laboratory, Department of Fisheries
(2) Customer Support & Laboratory Department, Australasia Marking Trading & Technology Co.,Ltd.

* World Health Organization Standard for drinking water (2006)

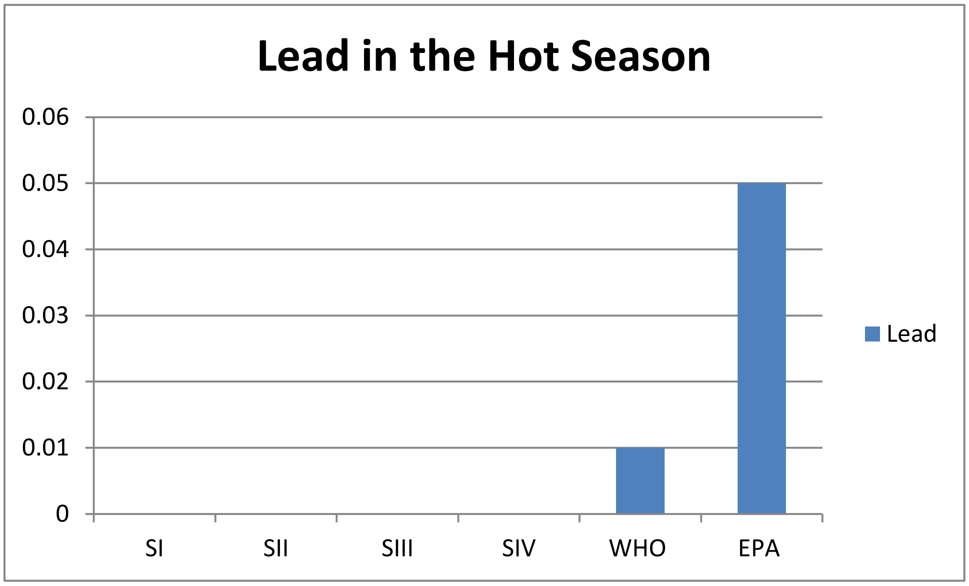
** Environmental Protection Agency for domestic water (2003)

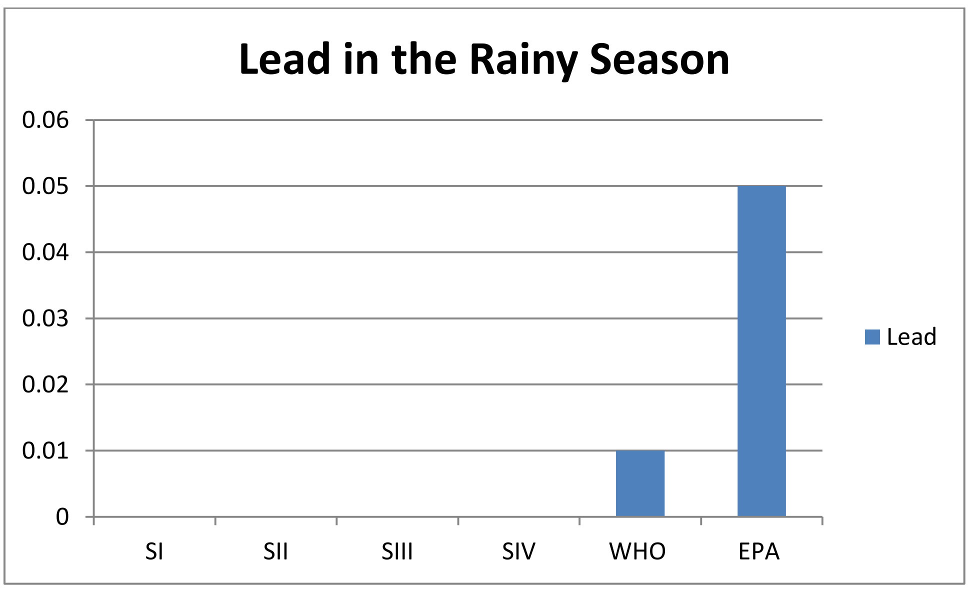
ND = Not detectable

4.6.3.1 Lead Content in Water Samples

The contents of lead in four collected water sample were not detectable in the hot season and the rainy season shown in the above table. These observed values are lower than the WHO Standard and EPA Standard. According to the EPA standard, lead in drinking water can cause a variety of adverse health effects children should not be exposed to lead in drinking water known to be above the action level of 0.05 mg/l.

Figure 4.14: Lead Content in Water Samples





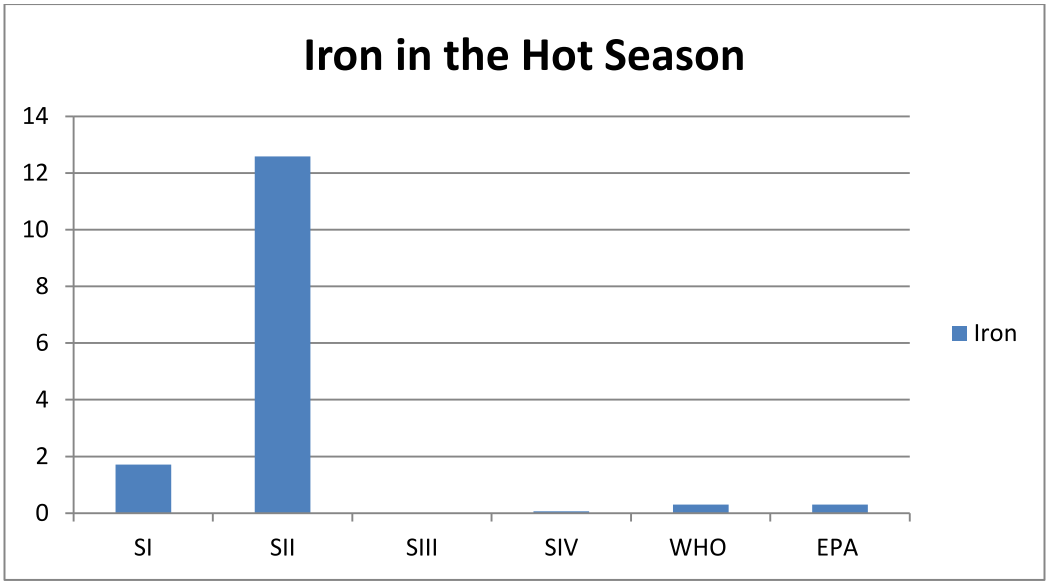
Source: Water Test Result from Laboratory

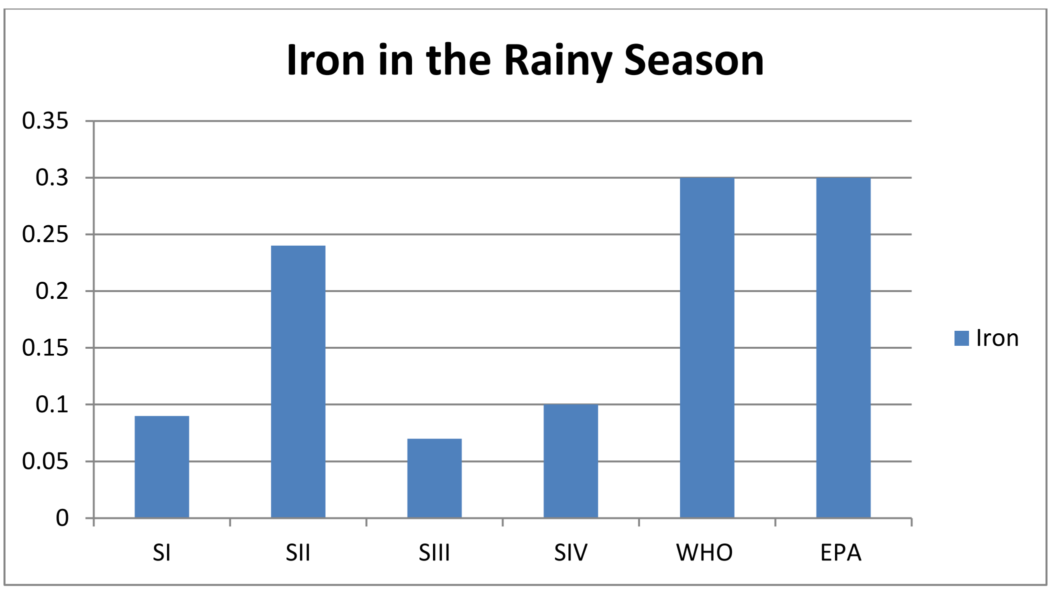
4.6.3.2 Iron Content in Water Samples

In the hot season, the iron contents in water samples were S_I water was 1.71 mg/l and S_{II} water possessed the highest level of 12.58 mg/l. S_{III} was not detectable and SIV was 0.063 in the hot season. The iron contents in the water sample S_{II} (tube-well 90 feet depth) was higher than but WHO and EPA Standards of 0.3mg/l.

In the rainy season, all water samples possessed lower value of iron than WHO and EPA Standards of 0.3 mg/l large amount of ingested iron can cause excessive levels of iron in the blood. High blood levels of free ferrous iron react with peroxides to produce free radical which are highly reactive and can damage DNA, proteins, lipids and other cellular components.

Figure 4.15: Iron Content in Water Samples



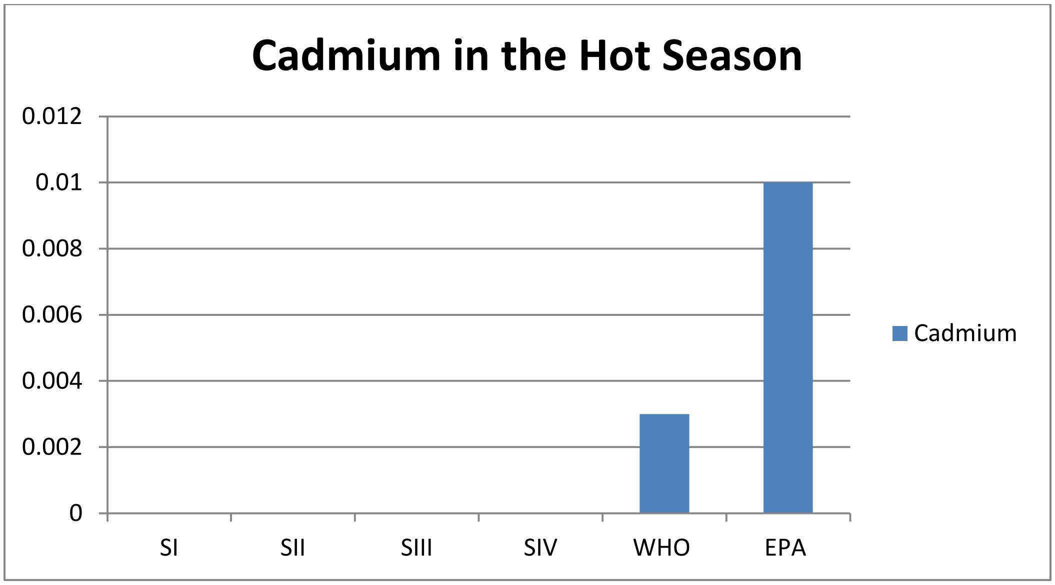


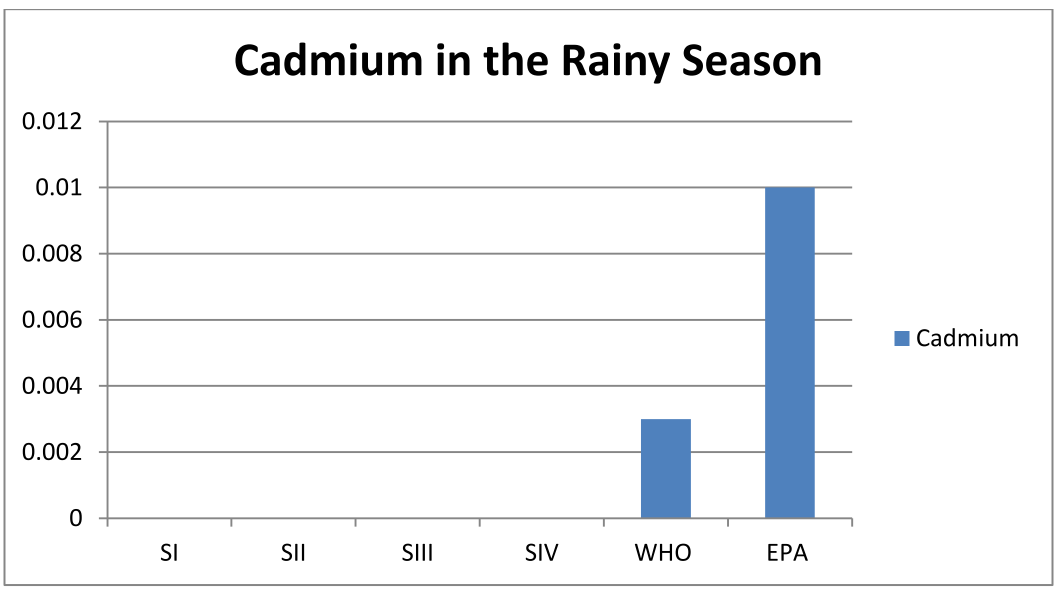
Source: Water Test Result from Laboratory

4.6.3.3 Cadmium of Water Samples

Sources of cadmium contaminant in drinking water are corrosion of galvanized pipes, erosion of natural deposits and discharge from metal refineries and run off from waste batteries and paints. In this study, the cadmium contents in all water samples were not detectable in both seasons.

Figure 4.16: Cadmium of Water Samples





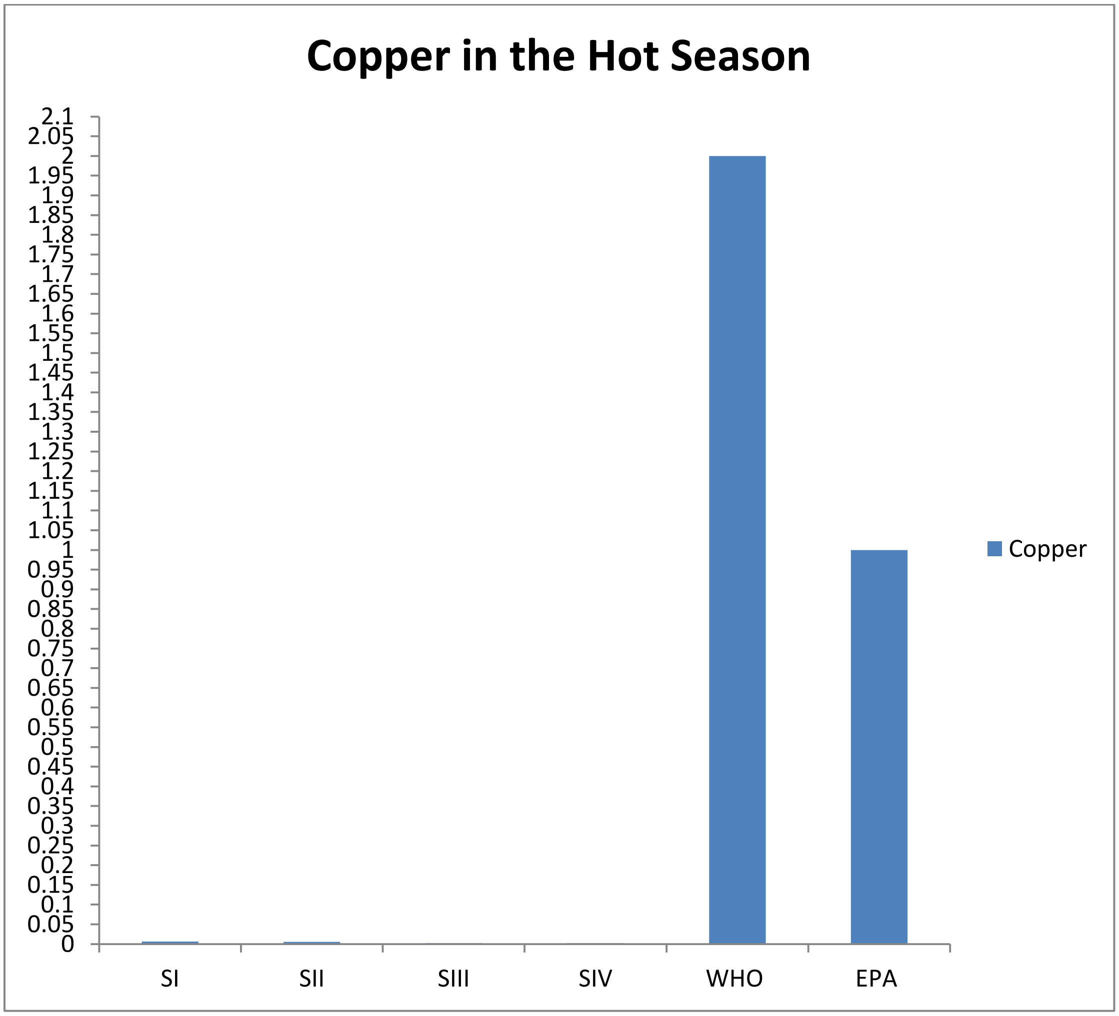
Source: Water Test Result from Laboratory

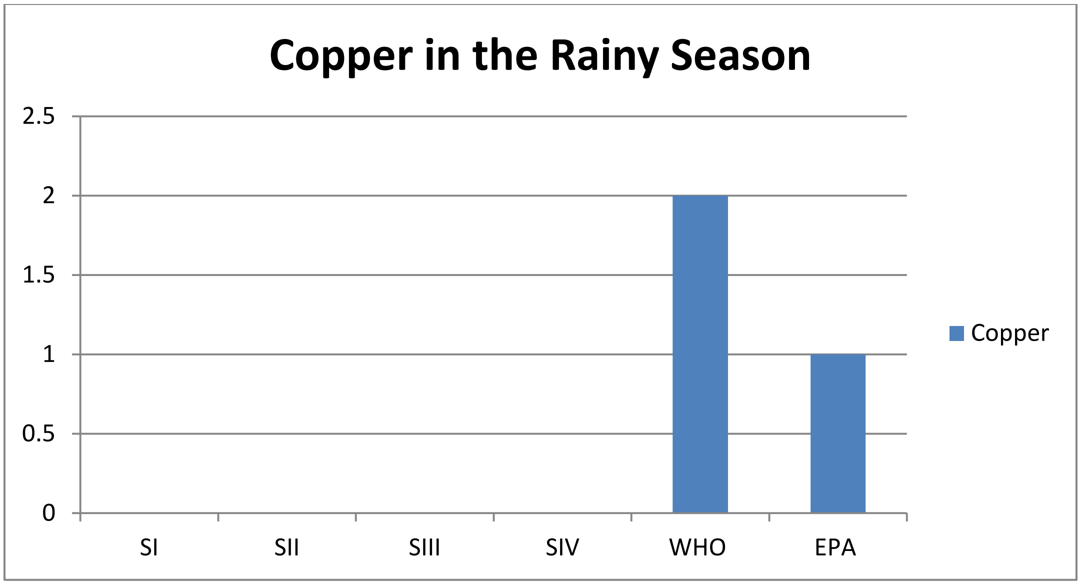
4.6.3.4 Copper of Water Samples

Copper in water samples were in the range of 0.002 mg/L to 0.006 in the hot season and were not detectable in the rainy season shown in the above table.

If there is higher copper level can cause the gastrointestinal distress in the short term and liver or kidney damage in long term. In this study, these values were lower than WHO and EPA Standards. So, all types of water are suitable for dinking and domestic use.

Figure 4.17: Copper of Water Samples





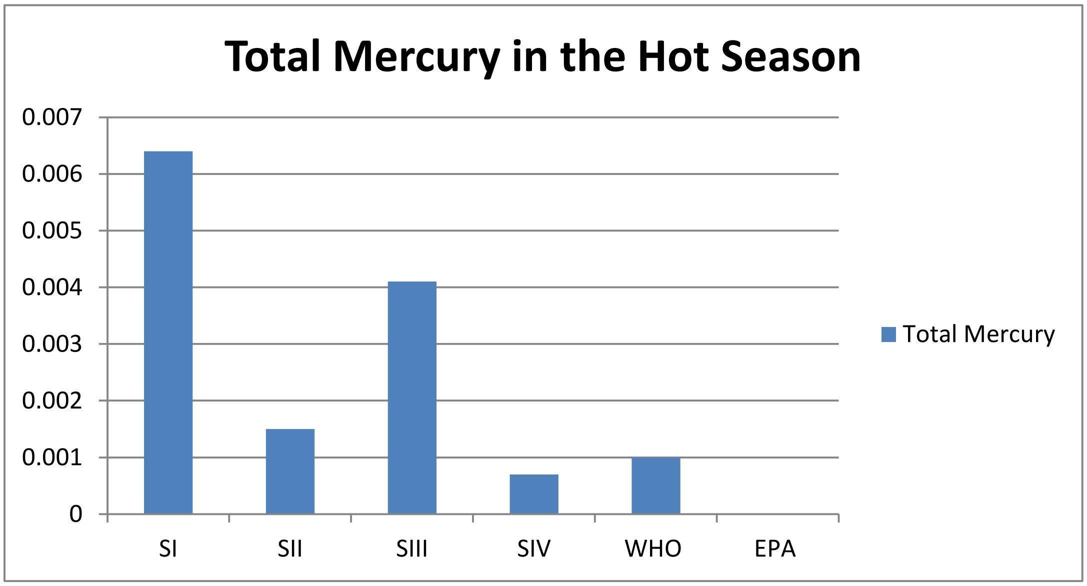
Source: Water Test Result from Laboratory

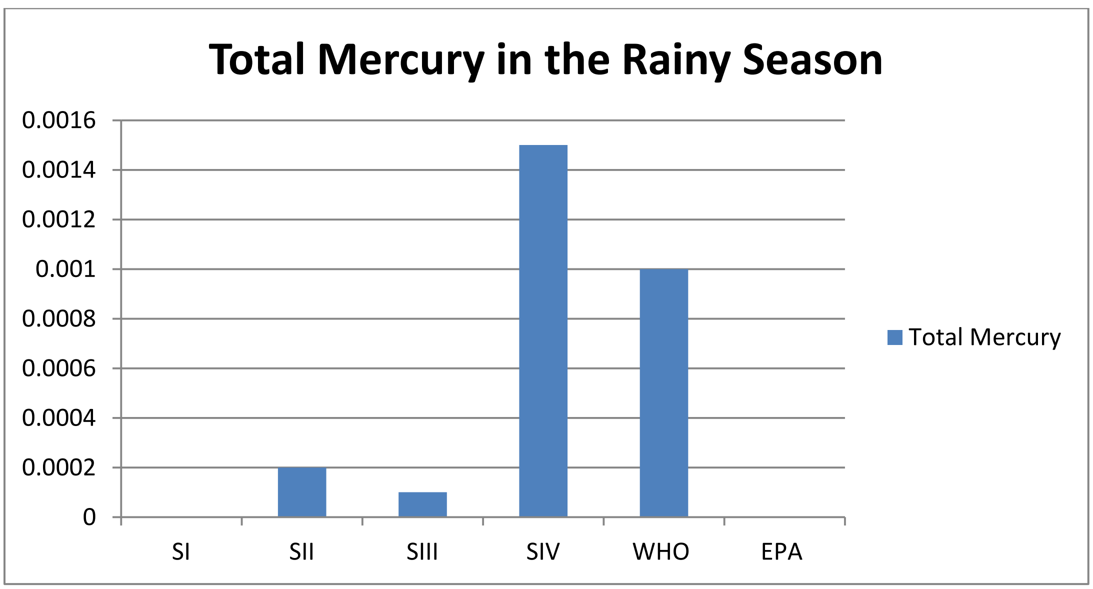
4.6.3.5 Total Mercury in Water Samples

Mercury is a liquid metal found in natural deposits such as ores containing other elements, erosion of natural deposits, discharge from refineries and factories, run off from landfills and croplands.

In this study, mercury contaminations in water samples were in the range of 0.0064 in S_I in the hot season but there wasn't detectable in the rainy season. For S_{II}, the value of mercury was 0.0015 in the hot season and fell to 0.0002 in the rainy season and 0.0041 in S_{III} in the hot season decreased to 0.0015 in the rainy season. But in S_{IV}, the amount of mercury rises from 0.0007 in the hot season to 0.0015 in the rainy season. This is shown in the above table and all of these values were lower than WHO and EPA standards value of 0.001 Hg.

Figure 4.18: Total Mercury in Water Samples





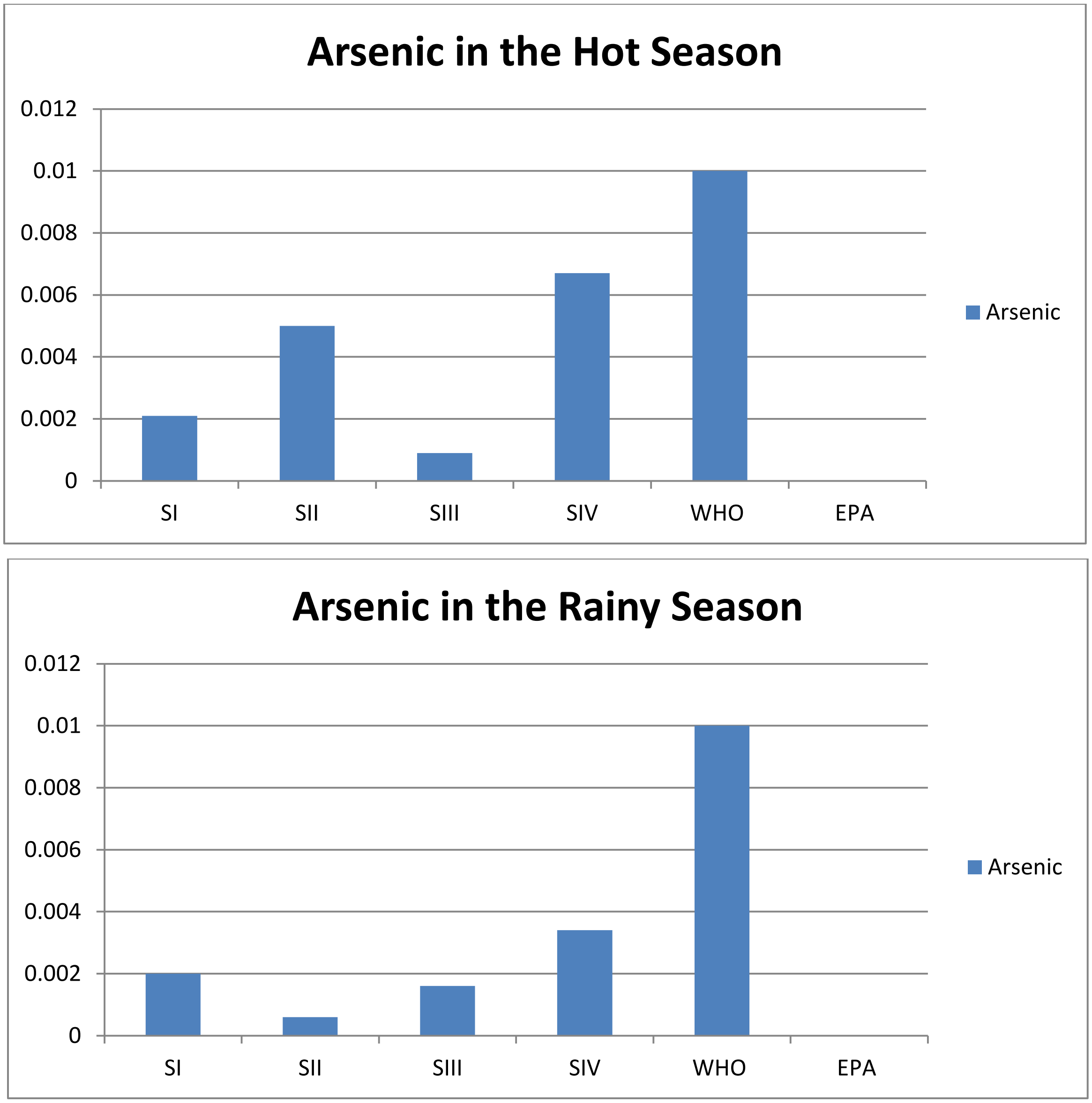
Source: Water Test Result from Laboratory

4.6.3.6 Arsenic in Water Samples

In the hot season, arsenic contamination in the water samples were 0.0021 ppm in S_I, 0.005 ppm in S_{II}, 0.0009 ppm in S_{III} and 0.0067 ppm in S_{IV}. In the rainy season, there were 0.0020 ppm in SI, 0.0006 ppm in S_{II}, 0.0016 ppm in S_{III} and 0.0034 ppm in S_{IV}.

If there is much arsenic content in water samples, it can occur skin damage or problems with circulatory systems and may have increased risk of getting cancer. In this study, according to the WHO Standard value of 0.01 mg/l, all water can use for drinking and domestic use.

Figure 4.19: Arsenic in Water Samples



Source: Water Test Result from Laboratory

4.6.4 Microbiological Parameters

Results of the experiments are presented in above table. It shows the microbiological parameters of the untreated water samples collected from four sampling sites in Industrial Zone and their disposal channels.

Table 4.11: Microbiological Parameters of Water Samples Collected from Industrial Zone (Hot and Rainy Season)

Para meter	Unit	Hot Season				Rainy Season				WHO Std *	EPA Std**
		SI	SII	SIII	SIV	SI	SII	SIII	SIV		
Total Coliforms	MPN/100 ml	$<10^3$	$<10^3$	$<10^3$	$<10^3$	0	0	46	210	0	-
E-coli	MPN/100 ml	0	0	0	0	0	0	0	0	0	-

Sources: (1) Laboratory of Small Scale Industries Department

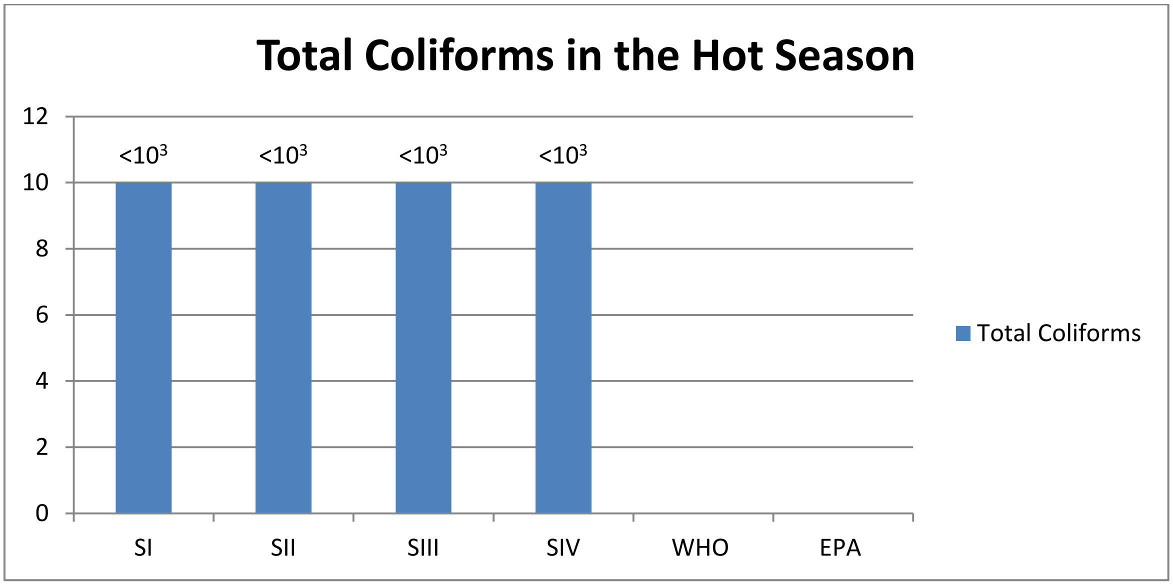
ND = Not detectable

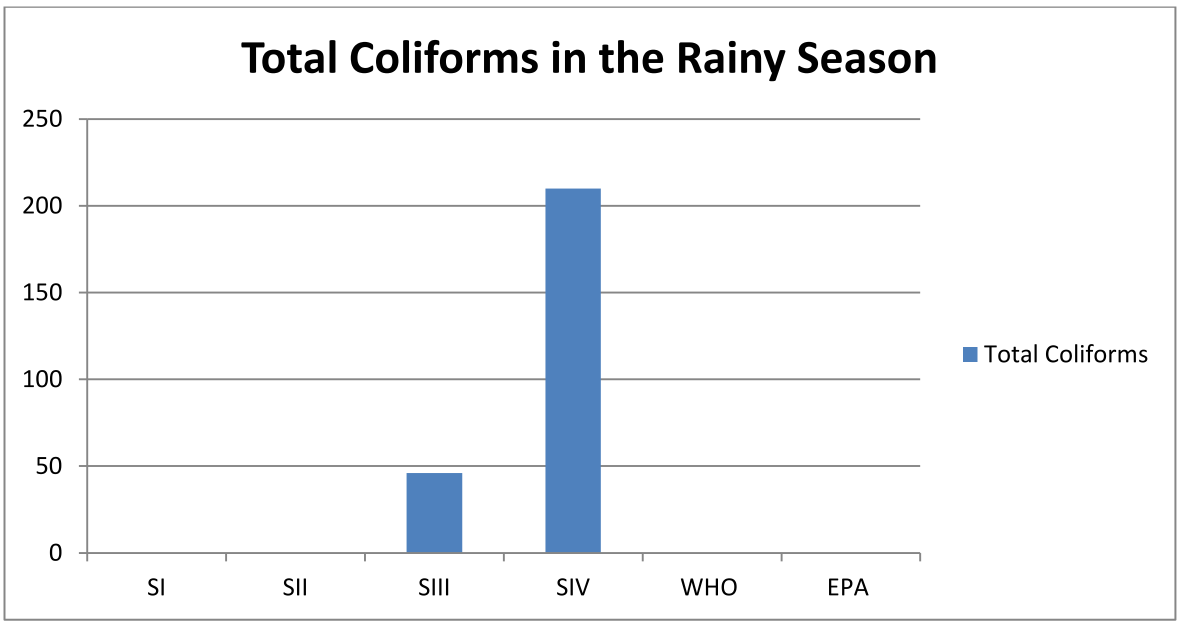
4.6.4.9 Total coliform in Water Samples

Bacteriological examination of water is more important than chemical and physical examination for drinking water purposes. The existence for concentration of pathogenic bacteria in water can render dangerous health.

In the present investigation, on the counts of coliform organisms of the all samples from S_I, S_{II}, S_{III}, S_{IV} were $< 10^3$ ml in the hot season and lake water S_I and tube-well (90 feet depth) S_{II} possessed amount of 0 but S_{III}, Joe-phyu water rise to 46 and S_{IV}, tube-well (400 feet depth) increased to 210.

Figure 4.20: Total coliform in Water Samples





Source: Water Test Result from Laboratory

4.6.4.2 E-coli in Water Samples

In this study, the E-coli contents in all water samples from S_I, S_{II}, S_{III}, and SIV were 0 in the hot season and the rainy season. According to these results, the water is not harmful for drinking and domestic purposes.

In this study, we had to choose (296) households for data collection using the systematic sampling method and test the four water samples which they are using daily in this area for the hot season and the rainy season. According to this study, there were (22) kinds of diseases are occurring in this area: They are typhoid, diabetes, liver disease, colic, yellow fever, epilepsy, cholera, cramp, nausea, heart disease, stomachache, arthritis, hay fever, neuritis, TB, asthma, skin problem, hypertension, diarrhea, dizziness, headache and fever.

In accord with the result of water test, we found the high value of parameters which can be harmful the human health such as turbidity, ammonia-nitrogen (NH_3N), cyanide, alkalinity, iron and chloride mainly in the Tube-well water (90 feet) and the bromine, turbidity, cyanide and alkalinity in the Lake Water (LW).

In the regression model, only three variables (Tube-well water (90 feet), disease caused by industry and distance of water sources from industry) are found to be significant. But they can explain about (74%) of the variation in medical expenses, (26%) of the variation is due to other factors which we could not explain. They could be due to personal hygiene, as well as the other environmental issues and lack of knowledge on health education etc. So, the result of water test and the regression analysis show that the diseases of dizziness, headache, fever, diarrhea, skin problems, asthma, nausea, typhoid and cholera are mostly related to the Tube-well Water (90 feet).

5.0 CONCLUSION

In this study, we found that Tube-well water (90) feet is not suitable for their daily use. As well as the government organization is lack of responsibility to monitor water quality in those water bodies where wastewater is discharged to regulate and to monitoring wastewater from the industrial zone.

The water distribution system in this area is very weak for the households. Most households have to use the impurity water and they have to spend their some income for the water sources. Although the residents suffer from the several diseases, two-third of the respondents does not exactly know that it is caused by water pollution. Because of they are uneducated and they team to use unclean water. As well as they have no enough knowledge that the diseases are related to the water pollution and water pollution can be occurred by the industrial zone and poor sanitation infrastructure especially bad garbage system, ill sewage system and poor drainage system.

According to this study, industrial zone is very close to this village group as well as the wastewater and byproducts released from the factories are not be disposed systematically. This fact can be harmful not only the health of the villagers but also the groundwater and environment. Nevertheless, we found that the households which use the water sources near the industrial zone suffer more diseases them the households away from the industrial zone.

This research report serves as a guide to reduce the health impacts of impurity water and wastewater disposing from the industries. Our hope is that our findings will help the authority to understand the existing problems and to implement the necessary policies and guidelines.

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