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IMPACT OF RAPID INDUSTRIALIZATION OF MANDALAY
ON DOKHTAWADY RIVER

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ABSTRACT

Analysis of water quality is required for pollution control, the assessment of environmental impacts for human beings. In this paper, it is pointed out that how the effect of industrialization of Mandalay Industrial Zone (II) impacts on Dokhtawady River. Water quality of three different sites and periods of Dokhtawady River were compared. These sites are near Shwesaryan Pagoda (Site-I), upper and lower places of Dokhtawady river that flowed Mandalay industrial sewage Ditch (Site-II and Site-III). The characteristic properties of water samples were studied by various analytical methods applying sophisticated instruments such as pH meter, spectrophotometer and conductivity meter. The physical and chemical parameters were determined such as colour, turbidity, pH, conductivity, total hardness, total alkalinity, total iron, manganese, chloride, and sulphate. Heavy metal contamination in water samples were detected by using Atomic Absorption Spectroscopic method. In addition, the biological examination of water samples was estimated. The results showed that the water samples were contaminated with some heavy metals.

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INTRODUCTION

All living beings depend largely on water for many purposes; the importance of water increases day by day as turn into the 21st century. It is the most familiar and occurs about 70% of the earth surface (Nordell, 1971). If any toxic substances or any substances, which are cause contamination of water, are present in drinking water, the consumers will be encountered great danger to health. There are so many complicated great dangers to health and health problems in connection with unwholesome water (K.N Duggl, 1971).

Dirty water is the world's biggest pollution problem and therefore, chemical investigations should be done on drinking water to determine its portability (A.K Chatterjee, 1975). Many countries can no longer manage pollution by dilution, leading to higher levels of aquatic pollution (E.W.Steel, 1960). The real and potential loss of development opportunity because of diversion of funds for remediation of water pollution has been noted.

The purpose of water analysis monitoring is to determine the physical, chemical and biological properties of natural water. The samples were collected from Dokhtawady river near Shwe Sar Yan pagoda in Patheingyi Township and upper and lower places of Dokhtawady River that flowed Mandalay industrial sewage Ditch, Sardaw Myothit Village in Myitnge Township. Dokhtawady river water contains industrial wastewater, agricultural waste, bacteria, other microorganisms, chemical, sewage and visible suspended matter.

In this research, physical parameters of water such as pH, color and conductivity were analyzed. Total hardness, alkalinity, metallic constituents and inorganic nonmetallic constituents were analyzed as chemical quality.

Aim and Objectives
Aim
       -To analyse the quality of water from Dokhtawady river water near Shwe Sar Yan Pagoda (Site-I), upper and lower places of Dokhtawady river that flowed Mandalay industrial sewage Ditch (Site-II and Site-III).
**Objectives**
   -       To collect the sample
   -       To determine the physical properties
   -       To investigate the chemical properties
   -       To perform the biological examination
   -       To examine the content of heavy metal lead and cadmium

EXPERIMENTAL
Sample Collection
       The water samples were collected from Dokhtawady river near Shwesaryan Pagoda (Site-I), upper and lower places of Dokhtawady river that flowed Mandalay industrial sewage Ditch (Site-II and Site-III) on August 2014 and December, 2014. The water samples were collected 20 feet apart from river bank and 2 feet depth. For collecting the samples, only well cleaned plastic bottle of capacity 20 liters were used. The collecting vessels in every case were rinsed with water which was to be collected.
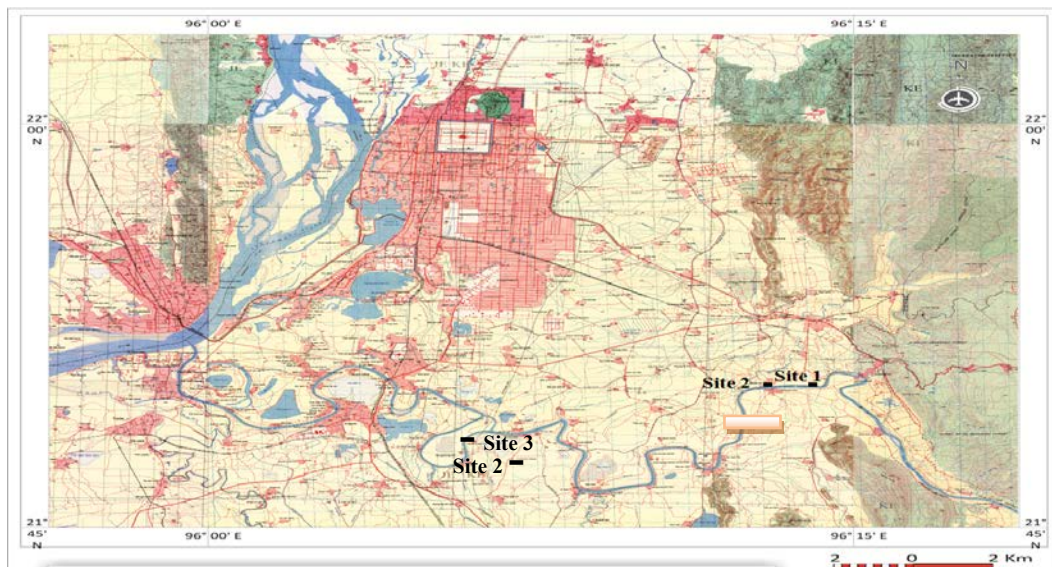
Figure 3.1 Collection of samples from Dokhtawady River

Analysis of Physical Properties of Dokhtawady River Water (L. Jean Bogert, 2007**)**
(Site 1, Site 2 and   Site 3)
Estimation of Color
       Color is determined by comparison of the sample with known concentration of colored solution .It is the standard method, the unit of color being that produced by 1 mg platinum /L in the form of the chloroplatinate ion. The color of water is extremely pH dependent and invariably increases as the pH of the water is raised. 25 ml sample was placed in the sample cell and the color was determined at 455 nm against 25 ml demineralized water as blank.

Estimation of pH value
       The basic principle of electrometric pH is determination of the activity of the hydrogen ions by potentiometric measurement using a glass electrode and reference

electrode. The various pH indicators exhibit a specific solution can be measured by a pH meter or by pH indicators .pH meter is an apparatus with electrodes sensitive to hydrogen (hydronium ions) .This instrument measures the small voltage produced by the presence of hydrogen ions and reads out the pH .

Electrodes were rinsed with distilled water and dried by gently cleaning with a soft tissue. The instrument was standardized with electrodes immersed in a buffer solution of pH 7. Then the pH of sample was measured by dipping electrodes after cleaning into well stirred sample for 1 minute.

Estimation of Conductivity

The reciprocal of resistance is conductance .Conductivity is a measurement of water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in water .The method of measurement used in the following procedure is by directed measurement with Eco Scan Con 5 conductivity Handheld meter. Conductivity may be expressed as microsiemens or mol/centimeter. 200 ml sample was placed in the beaker and the conductivity of the sample was directly measured by the conductivity meter.

Estimation of Total Dissolved Solid

A well mixed sample is evaporated in a weighed basin and dried to constant weight in an oven at $103° - 105°C$ .The increased in weight over that of the empty basin represents the residue.

The evaporating porcelain basin was cleaned thoroughly with concentrated nitric acid and washed with distilled water. The basin was dried in an oven at 200 °C for 1 hour. The basin was cooled, desiccated, weighed and stored in desiccators. 100 ml of water sample was quantitatively transferred to the pre-weighed basin and evaporated to dryness on a steam bath. Then the sample in the basin was dried in an oven at 103° to 105°C for 1 hour. The basin holding residue was cooled in desiccators and weighed. The cycle of drying at 103° to 105 °C, cooling, desiccating and weighing was repeated until the constant weight was obtained.

Calculation

$$\text{Total Dissolved Solid , mg/L} = \frac{(A - B) \times 1000}{\text{ml sample}}$$

Where,

A   =   weight of sample and basin in mg
B   =   weight of basin in mg

**Analysis of Chemical Properties of Dokhtawady River Water
(Site 1, Site 2 and   Site 3)**

Estimation of Total Hardness

Total hardness is defined as calcium and magnesium concentration both expressed as $CaCO_3$ in mg per liter. The EDTA titration method can be applied for the determination of hardness of water. If a small amount of a dye such as Eriochrome Black T (EBT) or calmagite is added to an aqueous solution containing calcium and magnesium ions at a pH of 10.00 ± 0.1, the solution becomes wine red. If EDTA is added as a titrant, the calcium and magnesium will be complexed and when all of the magnesium and calcium has been complexed the solution turns from wined red to blue making the end point of the titration.

Chemicals

(i) Erichrome Black T indicator

0.5 g of EBT was mixed with 4.5 g of hydroxylamine hydrochloride. This mixture was dissolved in 100 ml of ethanol.

(ii) EDTA (0.01 M)

3.723 g of disodium ethylene diamine tetra acetic acid (EDTA) was weighed and dissolved in distilled water and diluted to 1 liter.

(iii) Standard Calcium Solution

1.00 g of anhydrous calcium carbonate powder was weighed into a beaker. Concentrated HCl was added drop by drop to dissolved $CaCO_3$ powder and 200 ml of distilled water was added to the above beaker. The beaker was boiled for a few minutes to expel CO_2 .The solution was cooled and adjusted by adding NH_4OH or concentrated HCl as required to neutralize. The solution was quantitatively transferred to 1 L volumetric flask and dilute with distilled water. This standard solution was equivalent to 1.00 mg $CaCO_3$ per 1.00 cm^3.

1.00 cm^3 = 1.00 mg $CaCO_3$

(iv) Buffer Solution

16.9 g of NH_4Cl was dissolved in 143 ml concentrated NH_4OH .0.25 g of $MgSO_4$ .7 H_2O was dissolved in 50 ml of distilled water 50 ml of EDTA was added to $MgSO_4.7H_2O$ solution. Mix these two solutions and diluted to 250 ml with distilled water.

Procedure

50 ml of sample was pipetted to the conical flask 2 ml of buffer solution was added 2 drops of EBT indicator was added and the sample was slowly titrated by standard EDTA titrant until the last reddish tinge disappears from the solution. The end point color was blue.

Calculation

Hardness (EDTA) as mg $CaCO_3$ /L $= \dfrac{(A - B) \times 1000}{ml\ sample}$

Where,

    A = ml titrant for sample

    B = mg $CaCO_3$ equivalent to 1.00 ml EDTA titrant.

Estimation of Total Alkalinity

Alkalinity of the water is its quantitative capacity to react with a strong acid to a designated pH. Alkalinity of much surface water is primarily a function of carbonate, bicarbonate and hydroxide content .Hydroxide ions present in a sample as a result of dissociation or hydrolysis of solutes react with addition of standard acid. All hydroxide alkalinity and one half of the carbonate alkalinity are neutralized at pH of about 8.3 and all the carbonate and bicarbonate are neutralized at about pH 4.The volume of H_2SO_4 used to reach the end point in phenolphthalein titration is recorded as phenolphthalein alkalinity "P". Titration is continued using methyl orange indicator and the total volume from the beginning of the phenolphthalein titration gives the total alkalinity "T".

Chemicals

(i) Standard sodium carbonate solution (0.01 M)

1.06 g primary standard Na_2CO_3 was dissolved in 1 liter of distilled water.

(ii) Sulphuric acid solution

1 ml of concentrated sulphuric acid was diluted to 25 ml with distilled water. And then, sulphuric acid solution was standardized against standard Na_2CO_3 solution. After standardization, the concentration of H_2SO_4 was recorded.

(iii) Pnenolphthalein indicator

   0.5 g of phenolphthalein was dissolved in 50 ml of 95 % ethanol, 50 ml of distilled water was added to the above solution.

(iv) Methyl orange indicator

   0.05 g of methyl orange was dissolved in small quantity of distilled water and to 100 ml with distilled water.

Procedure

   20 ml sample was titrated with standard H_2SO_4 using phenolphthalein indicator until the color changed from pink to colorless. Then 2 drops of methyl orange indicator were added and the titration was continued until the color turned to faint red orange.

Calculation

Phenolphthalein Alkalinity (P) as Mg $CaCO_3$/L$=\dfrac{A \times B \times 50,000}{ml\ sample}$

Total Alkalinity (T) as $MgCaCO_3$/L $= \dfrac{A \times B \times 50,000}{ml\ sample}$

Where,

   A = ml standard acid used in phenolphthalein
   B = Total ml titrant used in both titration
   M = Morality of standard acid

Estimation of Calcium

   When EDTA (ethylenediamine tetra acetic acid or its salt) is added to water containing both calcium and magnesium, it combines first with calcium. Calcium can be determined directly with EDTA, when the pH is made sufficiently high so that the magnesium is largely precipitated as the hydroxide and an indicator is used that combine with calcium only. Several indicators such as murexide, Eriochrome, Blue Black R give a color a change when all of the calcium has been complexes by the EDTA at a pH of 12 to 13.

Chemicals

   a. sodium hydroxide solution, 1 M
   b. solid indicator mixture : 100g NaCl and 0.2 g murexide were ground to 40 to 50 mech
   c. EDTA titrant 0.01M
   d. (3.327 g dry disodium ethylene diamine tetra-acetate dehydrate per 1L distilled water)

Procedure

   25 ml sample was mixed with 25 ml distilled water 50ml of distilled water was taken as color comparison 2 ml of NaOH solution and 0.2 g of murexide indicator were added to the sample and blank 2 or 3 drops of EDTA titrant were added to the blank to obtain an unchanging color. The sample was titrated immediately with EDTA solution until the color changed as blank.

Calculation

$$mgCa/L \quad = \quad \frac{A \times B \times 400.8}{ml\ sample} \quad (or)$$

$$Ca\ hardness\ as\ mg\ CaCO_3/\ L = \frac{A \times B \times 1000}{ml\ sample}$$

Where, A = ml titrant for sample and

   B = mg $CaCO_3$ equivalent to 1.00 ml EDTA titrant at the calcium indicators end point

Estimation of Magnesium

Magnesium was estimated by using Calculation Method. It can be calculated by the following formula.

mgMg /L = [Total hardness as $CaCO_3$/L – Ca hardness as $CaCO_3$/L

Estimation of Sulphate

Sulphate is precipitated in hydrochloric acid as barium sulphate by the addition of barium chloride. The precipitate is carried out near the boiling temperature and after a period of digestion the precipitate is filtered, washed, ingnited or dried and weighed as $BaSO_4$.

Chemicals

(a) Hydrochloric acid , HCl

(b) Barium chloride solution

100 g $BaCl_2$. $2H_2O$ was dissolved in 1L distilled water and filtered through a membrane filter.

(c) Silver nitrate – nitric acid reagent

8.5g $AgNO_3$ and 0.85 ml conc:HNO_3 were dissolved in 500 ml distilled water.

Procedure

The pH of 150ml sample was adjusted with HCl to 4.5 to 5.1 to which 2ml HCl was added and heated to boiling warm $BaCl_2$ solution was added with stirring until precipitation appear to be complete , then about 2ml in excess $BaCl_2$ was added. A total of 5ml $BaCl_2$ solution was added wherever the amount of precipitate was small. The precipitate was digested to 80° to 90°C. The precipitate was filtered and washed with warm distilled water until washings were free of chloride as indicated by testing with $AgNO_3$-HNO_3 reagent . The precipitate was dried, ignited at 800°C for 1 hour, cooled in desicator and weighed.

Calculation

$$\frac{mgSO_4}{L} = \frac{mgBaSO_4 \times 411.5}{ml\ sample}$$

Estimation of Chloride

In a neutral or slightly alkaline solution, potassium chromate can indicate the end point of the silver nitrate titration of chloride. Silver chloride is precipitated quantitatively before red silver chromate is formed.

Chemicals

(a) Potassium chromate indicator,

50 g K_2CrO_4 was dissolved in a little water, $AgNO_3$ titrant was added until a definite red precipitate was formed. The solution was allowed to stand for 12 hours, filtered and diluted to 1L.

(b) Standard silver nitrate titrant, 0.0141M

(2.395 g $AgNO_3$ in 1L distilled water)

($AgNO_3$ titrant was standardized against 0.0141M NaCl solution)

Procedure

10 ml of sample was mixed with 90 ml of distilled water. 1 ml of K_2CrO_4 indicator solution was added and titrated with standard $AgNO_3$ solution to a pinkish yellow end point. The sample procedure was done with 100 ml of distilled water as blank.

Calculation

$$mgCl/L = \frac{(A - B) \times M \times 35450}{ml\ sample}$$

Where,

      A =   ml titrant for sample
      B =   ml titrant for blank and
      M =   molarity of $AgNO_3$
           (or)
    mgNaCl/L =   (mgCl/L) $\times$ 1.65

Estimation of Iron

      Iron is brought in ferrous state by boiling with acid and hydroxylamine and treated with 1,10 phenonthroline chelate, each atom of ferrous iron to form an orange red complex. A pH between 2.9 and 3.5 insures rapid color development in the presence of an excess of phenonthroline-color standards are for at least 6 months (H. Company, 1985).

Chemicals

    (i)   Concentrated HCI
    (ii) Hydroxylamine solution
        (10 g of NH_4OH, HCl in 100 ml distilled water
    (iii) Ammonium acetate buffer solution
        (250 g of CH_3COONH_4 was dissolved in 150 ml distilled water and 700 ml conc:glacial acetic acid was added)
    (iv) Sodium acetate solution
        (200 g $CH_3COONa.3H_2O$ was dissolved in 800 ml distilled water)
    (v) phenonthroline solution
        (100mg, 1,10 phenonthroline monohydrate $C_{12}H_8N_2H_2O$ was dissolved in 100 ml distilled water containing 2 drops of conc:HCl)
    (vi) Stock iron solution
        (20 ml conc: H_2SO_4 was added to 50 ml distilled water and 1.404 freeous amonium sulphate $Fe(NH_4)_2(SO_4)_2.6H_2O$ was dissolved 0.1 M $KMnO_4$ solution until a faint pink color persisted and dilute to 1L)
    (vii) Standard iron solution
    (50 ml stock iron solution was diluted to 1L with distilled water)

Procedure

      50 ml sample was taken in the conical flask and boiled with 2 ml conc: HCl and 1 ml hydroxylwamine reagent until the volume was reduced to 15-20 ml. It was cooled to room temperature and transferred to 50 ml nester tube. Then 10 ml of acetate buffer solution and 2 ml phenonthroline solution were added and diluted to the mark with distilled water after mixing thoroughly it is allowed at least 10-15 minutes for maximum color development. The color is measured spectrophotometrically at 510 nm.

      A series of iron standards were prepared by accurately pipetting the calculated volumes of iron working solutions (varying from 0.01 mg to 0.10 mg portions) into volumetric flask and diluted to 50 ml with distilled water. Then, experiment was carried out as in the case of sample .The color develops by standards are measured against distilled water set at 100 percent transmittance (zero absorbance) water a calibration curve in plotted including a blank. The observed spectrophotometer readings for sample are transformed into iron values by means of the calibration curve.

Bacteriological Examination of River Water Collected from Site 1, Site 2, and Site 3 on August

      The routine tests generally used in bacteriological examination of water are
  (1) A quantitative test for all coli-form bacilli known as presumptive coli-form count.
  (2) A differential test of typical coli-form bacilli (Eash.Coli) known as the differential coli-form test.

The samples were sent to the Public Health Laboratory, Mandalay and determination the bacteriological examination of water.

Estimate of Lead and Cadmium

The heavy metals such as lead and cadmium were determined by using atomic absorption spectroscopic method.

RESULTS AND DISCUSSION
Physical and Chemical Properties of Dokhtawady River Water Samples
(on August and December 2014)

Water qualities of different sites of Dokhtawady River were determined and the results were shown in Table (1) and Table (2).

The physical properties such as colour and the amount of total dissolved solid were found to be within W.H.O standards. The colour and conductivity of the water samples are the same. The amount of total dissolved solid of the water sample from Site-3 was found to be higher than that of Site-1.

The chemical properties such as pH, the amount of total hardness, total alkalinity, calcium, magnesium, sulphate and chloride were found to be within W.H.O standards. The amounts of the total hardness, calcium, magnesium, sulphate and chloride of the water samples are the same. The amount of total alkalinity of the water sample from Site-2 was found to be greater than that of Site-1. Iron was not detected on water samples. Due to the increase in total dissolved solid and total alkalinity, the water sample from site-2 was found to be more polluted.

Bacteriological Examination of Water Samples
(on August and December 2014)

Bacteriological Activities of water samples collected from site-1 and site-2 were examined and the results were shown in Table (3) and (4).

E Coli were isolated from all water samples. From the point of view of bacteria, the water samples were found to be unsatisfactory.

Comparison of Water Quality of Dokhtawady River Water Samples

The water samples were collected from site-3 on August and December 2014. Water quality of different periods of Dokhtawady River was determined and the results were shown in Table (5).

The physical properties such as colour and the amount of total dissolved solid were found to be within W.H.O standards (W.H.O, 2009). The colour of the water samples are the same. The amount of total dissolved solid of the water sample from December, 2014 was found to be higher than that of August, 2014.

pH of the water samples were found to be alkaline. The amounts of total hardness, calcium, magnesium, total alkalinity, sulphate and chloride of the water samples on December 2014 were greater than that of August, 2014. Due to the increase in these parameters, the water sample on December, 2014 was found to be more polluted than that of August, 2014.

Comparison of Bacteriological Examination

Bacteriological Activities of water samples collected from site-3 on August 2014 and December 2014 were examined and the results were shown in Table (6).

E Coli were isolated from all water samples. From the point of view of bacteria, the water samples on August, 2014 and December, 2014 were found to be unsatisfactory.

Comparison of Lead and Cadmium Contents

The amount of lead and cadmium were found to be decreased with each filtration using different types of adsorbents.

CONCLUSION

This investigation is to determine whether the water in Dokhtawady River used by most of the public is safe or not. Safe water must satisfy the criteria of being least harmful upon consumption. The water samples were collected from upper and lower places that flow Mandalay industrial sewage Ditch to Dokhtawady River, on August and December 2014. From the study of these parameters, the observed values are found to be inconformity with international Hand books for Drinking water proposed by WHO.

Based on collected area changed, the conclusion can be drawn for the present investigation of site 3 is most polluted than others. Even so, the water in site 3 must need proper treatment such as precipitation, chlorination or other disinfection method before using.

For assessing the bacteriological quality of water, these samples are given unsatisfactory remarks, as a precaution, consumers should at least boil the water before drinking. It is observed that the water from site 3 on December 2014 is highly polluted than others.

Moreover the amounts of lead and cadmium of water sample on December 2014 were found to be over permissible value.

According to these data survey, heavy metals such as lead and cadmium contamination were detected and bacteria were also found to be isolated in river water sample. Judging from these, it is seriously needed to save Dokhtawady River.

ACKNOWLEDGEMENTS

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Table (1) Comparison of Physicochemical Properties of Water Samples
from Dokhtawady River on August 2014

No	Test	Site 1	Site 2	Site 3	Highest desirable level	Maximum permissible level
1	Colour (Platinum, Cobalt Scale)	5	5	5	5	50
2	Conductivity micromhos/cm	220	220	220	-	-
3	Total Dissolved Solid (mg/L)	700	430	500	500	1500
4	pH	8.3	8.2	8.3	7.0 to 8.5	6.5 to 9.2
5	Total Hardness (mg/L)	160	160	160	100	500
6	Calcium(mg/L)	32	20	20	75	200
7	Magnesium(mg/L)	13	17	17	30	150
8	Total Alkalinity (mg/L)	455	260	325	600	950
9	Sulphate(mg/L)	98	78	78	200	400
10	Chloride(mg/L)	50	25	25	200	600
11	Total Iron	Nil	Nil	Nil	-	-

Table (2) Comparison of Physicochemical Properties of Water Samples
from Dokhtawady River on December 2014

No	Test	Site 1	Site 3	Highest desirable level	Maximum permissible level
1	Colour (Platinum, Cobalt Scale)	5	5	5	50
2	Conductivity micromhos/cm		-	-	-
3	Total Dissolved Solid (mg/L)	730	727	500	1500
4	pH	8.1	8.3	7.0 to 8.5	6.5 to 9.2
5	Total Hardness (mg/L)	300	300	100	500
6	Calcium(mg/L)	40	82	75	200
7	Magnesium(mg/L)	24	19	30	150
8	Total Alkalinity (mg/L)	390	390	600	950
9	Sulphate(mg/L)	186	196	200	400
10	Chloride(mg/L)	40	40	200	600
11	Total Iron	8.1	Nil	-	-

Table (3) The Results of Bacteriological Examination of Water Samples (on August, 2014)

No	Test	Site 1	Site 2	Site 3
1	Probable Coliform Count	5/5	5/5	5/5
2	*Escherichia Coli* Count	Isolated	Isolated	Isolated

Table (4) The Results of Bacteriological Examination of Water Samples (on December, 2014)

No	Test	Site 1	Site 3
1	Probable Coliform Count	5/5	5/5
2	*Escherichia Coli* Count	Isolated	Isolated

Table (5)   Comparison of Physicochemical Properties of Dokhtawady River Water

No	Test	August, 2014	December, 2014	Highest desirable level	Maximum permissible level
1	Colour (Platinum, Cobalt Scale)	5	5	5	50
2	Conductivity micromhos/cm	-	-	-	-
3	Total Dissolved Solid(mg/L)	500	727	500	1500
4	pH	8.2	8.3	7.0 to 8.5	6.5 to 9.2
5	Total Hardness (mg/L)	160	300	100	500
6	Calcium(mg/L)	20	82	75	200
7	Magnesium(mg/L)	17	19	30	150
8	Total Alkalinity (mg/L)	325	390	600	950
9	Sulphate (mg/L)	78	196	200	400
10	Chloride (mg/L)	25	40	200	600
11	Total Iron	Nil	Nil	-	-

Table (6)   The Results of Bacteriological Examination of Water   Samples on August, 2014 and December, 2014

No	Test	Results of August, 2014	Results of December, 2014
1	Probable Coliform Count	5/5	5/5
2	*Escherichia Coli* Count	Isolated	Isolated

Table (7) Comparison of Lead and Cadmium Contents (on December 2014)

No	Test	Site -1	Site -3
1	Lead(mg/L)	10.15	12.85
2	Cadmium (mg/L)	5.17	7.53