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Water Quality of River Tungabhadra due to the Discharge of Industrial Effluent at Harihar, District Davanagere, Karnataka State, India

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ABSTRACT

Water is a prime mover of all activities and essential feature for all modern developments. Water is distributed in different forms, such as rain water, river water, spring water and mineral water. Rain water is considered to be the purest form, however, is associated with dissolved gases such as CO_2, SO_2, NH_3 etc., from atmosphere. Water used for Industrial development and municipal purposes, it is better to ensure the quality of water for these purposes. There is influence of Industrial waste. Sewage on the water quality, the waste products can change the water Chemistry. Water gives life to Industries, but, Industries kill the water Chemistry. The waste water which emerges out after uses from industries have no definite composition, the pollutants associated with industrial effluents such as organic matter, inorganic dissolved solids, fertilizer materials, suspended solids, heavy metals from toxic pollutants and micro organisms and also pathogens. The industrial wastes are responsible for water color, turbidity, odour, hardness, toxic elements, bacteria and micro organisms. Industrial wastes contain poisonous chemicals which are difficult to remove from its homogeneous solution state.

Keywords: Odour, Turbidity, Power of Hydrogen, Chloride, Sodium (Na), Potassium (K), Acidity, Sulphate (SO_4).

INTRODUCTION

Rivers are life line of living being and constitute an integral part of both rural and urban community as a source of drinking and cooking purposes. Water used by the public must be free from disease causing bacteria; toxic chemicals, excessive

amount of minerals and organic matter[1]. Fresh water becomes polluted due to three major reasons, excess nutrients from sewage, industries, mining and agriculture. According to recent investigations ground water contamination also increasing due to anthropogenic activities like disposal of waste, sewage, industrial waste[2]. Due to rapid Industrialization, Urbanization, therefore, pollution of water resources needs a serious and immediate attention through periodical check up of water quality.

Keeping in view the main objective of the present investigation is the evaluation of physico-chemical aspects of Tungabhadra River water from the selected locations at Harihar Polyfibre Industries, to specify accurately and timely information regarding the quality of river water at industrial effluent disposal point and both at upstream and downstream flow of water. The present findings may be helpful to shape sound public policy and to implement water quality improvement programme effectively as well as efficiently.

Study area

The two Major Industries are discharging their effluents in the river Tungabhadra at Kumarpattanam near Harihar town, District Davanagere, Karnataka State.

1. Harihar Polyfibers Factory (HPF) is the largest Rayon grade pulp manufacturing unit in India (1972). Daily manufacturing capacity approximately 200 tones, generating more than 30 thousands liters of industrial effluents per day.
2. Grasilene Rayon Factory (GRF) 1977 produces about 850 tones of Grasilene fiber per month generating about 10 thousand liters of highly polluted effluents.

Both factories locating on the left bank of river Tungabhadra on NH-4 at Kumarpattanam. The area selected for studies are up stream flow of water from discharge point, discharge point and downstream flow of water from the effluent disposal point. The water quality of upstream investigated for the comparative study of effluent effect on water body. The partially treated effluent run in one canal for a distance of half km through a small village called Nalavagal, before joining the river Tungabhadra at only one location. The waste water was colored before mixing with river water, carrying lot of foam along the downstream, recently the treatment of effluents from these two factories are adapted little new technology or discharging into river without any proper treatment before discharging.

People residing in these areas utilize river water for their daily needs. Sampling locations were selected on the basis of the detailed survey of the study area and discussion with local public, the details regarding the locations is given in Table 1.

EXPERIMENTAL

All the samples were collected in clean polythene bottles with necessary precaution and brought to the research Laboratory without the addition of any preservatives and subjected to the physico-chemical analysis within 24 hours after collection, in order to assess their quality and portability water samples were analyzed using standard methods[2,3,4]. All the chemicals used were A.R. Grade; Double distilled water was used for the preparation of various solutions. The physico-chemical parameters such as Temperature, pH, EC, TDS, DO, TH, TA, Calcium, Magnesium, Sodium, Potassium, Chloride, Nitrate and Sulphate were determined by standard procedures[5]. The pH and EC were carried out by using pH-meter and Electrical conductivity meter respectively. Sodium (Na^+) and potassium (K^+) were determined

by using flame photometer; sulphate (SO_4”) ion concentration was determined by using visible spectrophotometer.

RESULTS AND DISCUSSION

The assessed physico-chemical parameters after the analytical determination given in Table 2 to Table 5. The values were compared with the standard values given by WHO[6], ISI[7] and with ICMR[8] as given in Table 6. The water samples collected at upstream (spot 1) were not having any objectionable color appearance, taste or odour during the monitoring periods (August- 2013, September- 2013, October- 2013 and November- 2013). The samples collected at the industrial disposal point the water is found in thick dark brown coffee colored before mixing with river water, carrying lot of foam along the downstream. The water samples at the downstream from the discharge point were collected and the analyzed. The results indicate the river water under goes natural purification during its flow along the stream.

Temperature

All physiological activities and life processes of aquatic organisms are generally influenced by water temperature[9], it is an important parameter because effects bio-chemical reactions in aquatic organisms. A raise in temperature of water leads to the speeding up of chemical reactions in the water body. Temperature reduces the solubility of gases and amplifies the tastes and odours. In the present investigation the temperature range was found in between 26.9^{o}C to 28.30^{o}C at the industrial effluent discharge point. The temperature of upstream water found in between 26.6^{o}C to 27.8^{o}C where as downstream water temperature at spot S3 and S4 were in between 26.4^{o}C to 29.1^{o}C.

Taste and Odour

Disagreeable odour and taste in water may be because of the presence of vegetation, inorganic constituents and organic matters, the discharge of waste water and industrial effluents in water bodies. WHO and BIS limit: unobjectionable or agreeable due to aesthetic condition. But, at the present studies water samples were found to be odourless, whereas the water chemistry was spoiled at the discharge disposal point. Downstream water under gone the natural purification possessing tasteless and odourless characters.

Turbidity

Turbidity in water is caused by suspended matter finely divided organic and inorganic matter, soluble colored organic compounds are responsible for the developing the turbidity in water. Plankton and other microscopic organisms make the water turbid. Turbidity was found to be O NTU. WHO and BIS limit: 5-10 NTU; aesthetic consideration and harmful bacteria may be associated with particles. In the present study the water sample at industrial effluent disposal point was found to be in colored due to industrial waste and finely divided organic and inorganic matter.

pH (Power of Hydrogen)

The pH of natural water is important index of hydrogen ion activity and it is resulting value of the acid - base interaction of a number of mineral and organic components in water. pH is an important ecological factor and is a term used and universally to express the intensity of the acid and alkaline condition of the water samples. Most of the water samples were slightly alkaline due to the presence of carbonates (CO_3’’) and bicarbonates (HCO_3’). pH-value determines the equilibrium between free CO_2, HCO_3’ and CO_3’’. The present study reveals that the pH of upstream water found in between 7.2 to 7.4, where as in downstream water was found

to be in between 7.6 to 8.3 indicates more alkaline in nature and may reflect contamination of OH- ions by strong bases such as sodium hydroxide and calcium hydroxide10. At the disposal point the pH of water was ranged from 7.0 to 7.3 (WHO and BIS limit: 6.5 to 8.5; health reflect problem, may affect mucous membrane and problem in water supply system).

Electric Conductivity (EC)

Electric conductivity is caused due to presence of electrolytes which dissociate in to cations and anions, It is a measure of water capacity to convey electric current. It is an indicator of the degree of mineralization of water. The EC is correlated with total dissolved solids[11]. It signifies the amount of total dissolved salts. Presence of high amount of dissolved inorganic substances in ionized form.

In the present investigation the EC-values of water sample at the industrial effluent point during monitoring periods ranged in between 789 to 2896 μ mhos/cm, and indicate the presence of some ionic matter such as Ca, Mg, Cl, SO_4, CO_3, HCO_3 and some trace elements.

The EC-values of upstream and downstream water samples were in the legal limit, most of the water sample content substantial amounts of dissolved CO_2, HCO_3' and hydroxides, these constituents are the results of dissolution of minerals in the soil and atmosphere[12].

Density, Surface Tension and Viscosity

Density of the water samples at the disposal point was 0.9982 gram/cm^3, while surface Tension was 71.812 dyne/cm. Viscosity of water sample was calculated as 0.0091 poise/cm/sec. which was in the comparable ranges.

Total dissolved solids (TDS)

TDS is an index of solid present in dissolved form and estimated as being 0.5 to 0.9 times the conductivity in ms/cm. It indicates the salinity behavior of ground water. Water containing more than 500 ppm of TDS is not considered desirable for drinking water supplies, but in unavoidable case 1500 ppm is also allowed[13] for domestic use. In the present investigation the TDS values of upstream water samples at various monitoring months found in between 78 ppm to 97 ppm. The downstream water samples are also found in the normal prescribed legal ranges ie., in between 129 ppm to 589 ppm, where as the TDS values of water sample at the industrial effluent point was ranged in between 787 ppm to 2896 ppm, more than the proscribed value, this indicates that the factory effluents contains large amount of dissolved solids, this salinity behavior of water sample due to the dumping of chemicals both organic and inorganic matter in to the river water. (WHO and BIS limit: 500 ppm -2000 ppm; palatability decrease and may cause gastro intestinal irritation).

Dissolved Oxygen (DO)

Oxygen is a regulator of metabolic processes of plants and animals. The depletion of oxygen level is due to high amount of organic wastes and industrial wastes. In the present investigation water samples at the industrial effluent discharge point their DO values found to be in between 1.8 ppm to 3.8 ppm during the monitoring months. While the upstream water showed the DO values in between 6.0 to 6.9 ppm and the downstream water showed the DO values in between 4.3 ppm to 6.6 ppm this indicates the river water gets natural purification. The lower value of DO at the effluent discharge point water may be due to inclusion of high inorganic and organic load in the water which leads to oxygen depletion.

Total Hardness (TH)

The total hardness may be due to the presence of divalent cations like Ca, Mg found abundant in water. The total hardness is sum of the calcium and Magnesium concentrations, both expressed as Calcium carbonates in ppm values. Water is conventionally classified as hard or soft from the following classification 50-100 ppm (Soft), 100-250 ppm (Moderately hard), 250-350 ppm (Hard). Hardness is the property of water which prevents the later formation with soap and increases the boiling points of water[14].

In the present investigation the TH of the upstream water samples ranged in between 45 ppm to 68 ppm. Similarly the TH values of downstream water found in between 65 ppm to 178 ppm during the monitoring periods. Whereas the water samples at industrial effluent point showed TH range was from 194 ppm to 330 ppm. Thus the water samples were found to be moderately hard and thus need to be treated before using it for the domestic uses.

Calcium and Magnesium Hardness

The water samples collected at the industrial effluent discharge point contain the calcium hardness from 87 ppm to 172 ppm these values were close resembling and were within the permissible limit. Magnesium hardness values from 18 ppm 54 ppm and were within the permissible limit of 30 to 150 ppm (WHO). Jain *et al*[15] and other reported that the high concentration of hardness (150 to 300 ppm) may cause heart disease and kidney problems.

Alkalinity

Alkalinity of water is acid neutralizing capacity of the water to predestinated pH. Alkalinity in water is mainly due to CO_3'' HCO_3' and OH- content. Borates, phosphates, silicates or other bases if present also contribute for alkalinity. (WHO and BIS limit: 200 to 600 ppm; taste become unpleasant). In the present study the water samples collected at disposal point the total methyl orange alkalinity was found in between the range was within the prescribed limits.

Biological Oxygen Demand (BOD)

Biological oxygen demands are a measure of the quantity of oxygen used by microorganisms (aerobic bacteria) in the oxidation of organic matter. In the present work the BOD values of water samples during the monitoring periods at the industrial effluent disposal point was found in between 74 ppm to 112 ppm, this indicates the effluent runoff carries chemical wastes during the polyfibre synthesis. This is due to the discharge of untreated or partially treated industrial effluent directly in to the river. There is makeable variation in the BOD content along the downstream from the discharge point during the study period which was ranged in between 20.1 ppm to 36 ppm. The upstream water showed low BOD values 3.1 ppm to 6.4 ppm. The decrease in BOD and increase in DO from effluent discharge point was due to natural self purification.

Chemical Oxygen Demand (COD)

COD determines the oxygen required for the chemical oxidation of organic matter. COD values conveyed the amount of dissolved oxidizable organic matter including non-biodegradable matter present in it. The COD value in the sample effluent was found to be 122 ppm to 179 ppm; the high COD value determines the organic load. The COD values found within the 10 ppm to 24 ppm found within the permissible limit.

Chloride (Cl^-)

The chloride concentration serves as an indicator of pollution by sewage, industrial effluents. Chloride occurs in all ground waters widely in varying concentration. Excessive

chloride in potable water is not particularly harmful. Chloride in excess (more than 250 ppm) imparts a salty taste to water. People accustomed to higher chloride in water are subjected to laxative effects[16]. In the present investigation the chloride values ranged from 26.5 ppm to 36.8 ppm from the upstream water samples, and chloride found in between 31.08 ppm to 54.5 ppm along the downstream water. Whereas the chloride content of the water samples collected at the effluent discharge point ranged in between 123 ppm to 276 ppm, slight more than the permissible legal range. The tolerance of chloride by human being varies with climate, exertion and loss through perspiration. (WHO and BIS limit: 250 to 1000 ppm decreases pot ability, salty taste and corrosion).

Sodium (Na)

Sodium levels in ground waters vary widely; depends upon geological formation. In surface water generally the sodium concentration ranges in between 1 and 300 ppm depending upon the geographical area. Excessive intake of sodium chloride causes vomiting. (Guideline values: 200 ppm; based on taste threshold and health consideration). In the present investigation the sodium concentration of the water samples collected from upstream water, at the industrial effluent disposal point and water samples of downstream were found in between the ranges of 20 ppm to 34 ppm, 59 ppm to 110 ppm and 26 ppm to 54 ppm respectively, this indicates the more concentration of sodium in the industrial effluent point due to the chemical combination of compounds leads to change in the quality of water.

Potassium (K)

The quality of water in the natural process most commonly found the concentrations of both sodium and potassium. The concentration of potassium is quite lower than sodium. It remains most common in solution without undergoing any precipitation. The potassium concentration of upstream river water sample found to be very low i.e., less than the prescribed limit. Whereas the potassium concentration in water sample collected at discharge point found in between 26 ppm to 30 ppm also less than legal range. The concentration of potassium falls with the downstream due to the natural purification.

Acidity

Acidity is a measure of the effects of combination of compounds and conditions in water. It is the power of water to neutralize OH- and is expressed in terms of $CaCO_3$. Water attains acidity from industrial effluents, municipal waste (drainage) and from humic acid. No phenolphthalein acidity and methyl orange acidity was found in the studied water samples.

Pathogens

The most common danger associated with drinking water is contamination by sewage, by other waste or by human or animal excreta. In general this is determined by conducting test for total coli form counts, fecal coli form counts. The pathogen observed was salmonella species which is gram negative and short rod shape. (BIS limit: 10 CFU/ 100 ml and absent; causes illness and fatal for life).

Sulphate (SO_4)

In the present investigation sulphate concentration of upstream water sample was recorded and ranged in between 8 ppm to 17 ppm. In downstream water was ranged in between 94 ppm to 280 ppm. The SO_4 content in the water sample collected at the discharge point found in between 194 ppm to 330 ppm. All the values found within the permissible limits. It is known that the sulphate concentration in water samples around 1000 ppm; it has Laxative effect and

causes gastrointestinal irritation[17]. Excess Na_2SO_4 in water causes cathartic action. High concentration of Na and $MgSO_4$ is associated with respiratory illness.

Iron (Fe)

Iron is an important essential element to human body which is present in hemoglobin and myoglobin. When iron concentration exceeds permissible limit in drinking water it gives stringent taste to water. According to WHO standards, limit of Fe concentration in drinking water is 0.3 mg/L, exceeding which causes toxicity. In the present investigation the iron content of the water samples analyzed was found to be more than the permissible limits. These values vary from 1.56 ppm to 2.08 ppm and indicate the effluent consists with more iron content because of using chemical compounds in industrial process.

Copper (Cu)

Copper is essential element of human body, but excessive large doses may lead to mucosal irritation, corrosion, wide spread capillary damage, hepatic and renal damage and also to central nervous system. Copper below 20 µ gram/L may found in drinking water. Due to the industrial effluent concentration of copper in water may increase. The concentration of copper found in natural waters is not known to have adverse effects on humans. Though copper in excess of 1.0 mg/L may impart some taste to water18. Toxicity of copper to aquatic life is dependent on the alkalinity of water. At lower alkalinity, copper is more toxic to aquatic life. In the present investigation the concentration of copper recorded a maximum 0.09 ppm at industrial effluent disposal point.

Zinc (Zn)

Zinc is an essential element and it is necessary for the functioning of various enzyme systems, deficiency and low intake of Zinc of which results in retardation of growth, immaturity and anemia, condition known as "Zinc deficiency syndrome". Symptoms of Zn toxicity in humans include vomiting, dehydration, abdominal pain, dizziness and lack of muscular coordination. Zinc imparts undesirable bitter astringent taste to water at levels above 5.0 m gram/L. zinc deficiency in human body may result in infantilism, impaired wound healing and several other diseases. Pollution from industrial sources to a great extent is responsible for high concentration of zinc in water. The concentration of zinc in the study area (at discharge point) ranges from 1.50 ppm to 4.95 ppm which below the prescribed limits.

Manganese (Mn)

Excess Manganese in a diet prevents the use of Iron in the regeneration of blood hemoglobin. Large doses of Manganese cause apathy, irritability, headaches, insomnia, and weakness of the legs.

Psychological symptoms many also develop including in impulsive acts, absent-mindedness, hallucinations, aggressiveness and unaccountable laugher. Finally a condition similar to Parkinson's disease may develop19. Manganese Pollution from HPF industrial effluent discharging of chemical waste at disposal site was analyzed, the concentration of Manganese in the study area ranged from 0.21 to 0.42 mg/L [BIS Limits: 0.30 mg/L]. Hence, Manganese-values exceed this limit at some monitory period. Thus, the quality of water is suspect able for drinking and other domestic Purposes. The other elements such as Cobalt and Nickel are also important and essential to human body.

CONCLUSION

- Data reveals that the river water polluted to some extent at the industrial effluent discharge point, as indicated by a very high value of COD and other activities.

The data also indicates that the water bodies total hardness were sound to be beyond the permissible limits as prescribed by WHO and other standards.

- Qualitatively the water in the studied area is not potable, hard and chemical mixed at the discharge point. Hence, the water at this area is may be used for irrigation but not for domestic and drinking purposes.
- From the analysis it may be concluded that proper environment management plan may be adopted to control the release of effluent. Hence, it is suggested to exercise all the necessary precaution before the water is used for domestic and irrigation. Otherwise it may lead to much adverse health effect.
- To improve or to keep the quality of water at the effluent discharge point, the industrial waste should be treated properly before disposal into the river stream. Hence, there should be continuous monitoring of the pollution level.
- The polluted water due to the disposal of industrial effluent, used for irrigation which would not improve the soil fertility but also reduces the enrichment of nutrients present in the soils.
- The Figures 1 to 3 indicate the comparative studies in the variation of the physicochemical parameters and presence of trace elements in the water samples at various selecting points. The result implies the water sample at industrial effluent discharge point found more polluted rather than upstream, the water in the downstream itself gets natural purification.

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Table 1. Details of sampling locations

No.	Stream	Sampling location	Distance from discharging point.
1	Upstream	Harihar side (Makanur)	0.5 km.
2	Discharge point	Factory point	50 feet
3	Down stream	Nadiharalahalli	0.5 km.
4	Down stream	Airani	5 km.

The average values of Physico-chemical parameters and Trace elements in the study

Table 2. Location: upstream (Spot 1) 0.5 km. from discharge point towards Harihar- side

Date	Temp.	pH	EC	TDS	COD	BOD	DO	Cl^-	CO3''	HCO3'	Calcium
25.08.13	26.6	7.3	298	97	24	6.4	6.0	36.8	ND	2.1	22
22.09.13	27.8	7.4	162	96	16	6.3	6.6	28.0	ND	2.2	15
26.10.13	27.5	7.3	181	88	19	3.5	6.8	26.5	0.7	2.6	26
24.11.13	26.6	7.2	149	78	10	3.1	6.9	34.0	0.6	2.8	18
Date	Mg	Na	K	SO4''	TH	Zn	Cu	Fe	Mn	Cobalt	Nickel
25.08.13	5.0	34	7	08	65	0.189	0.03	0.85	0.14	0.04	0.10
22.09.13	3.2	20	4	12	68	0.281	0.06	1.04	0.16	0.06	0.09
26.10.13	4.0	24	5	17	45	0.314	0.02	0.98	0.09	0.06	0.02
24.11.13	3.2	21	6	14	68	0.201	0.09	0.92	0.12	0.06	0.13

Table 3. Location: Discharge point (Spot 2) 50 feet away from the factory

Date	Temp.	pH	EC	TDS	COD	BOD	DO	Cl^-	CO3''	HCO3'	Calcium
25.08.13	28.0	7.2	2896	1388	172	74	1.8	123	0.5	13.4	152
22.09.13	28.0	7.3	1099	1622	122	107	2.9	127	0.8	9.92	172
26.10.13	27.9	7.2	798	898	130	112	2.8	226	1.36	6.67	95
24.11.13	26.9	7.0	787	1012	179	105	3.8	276	1.80	12.8	87
Date	Mg	Na	K	SO4''	TH	Zn	Cu	Fe	Mn	Cobalt	Nickel
25.08.13	39	89	30	330	21	4.95	0.07	1.56	0.34	0.12	0.86
22.09.13	54	110	28	194	194	2.98	0.09	2.08	0.25	0.84	0.92
26.10.13	18	92	27	230	330	1.50	0.07	1.58	0.21	0.18	0.20
24.11.13	22	59	26	270	250	3.15	0.09	1.71	0.42	1.98	0.19

Table 4. Location: Downstream (Spot 3) Near Nandihalli village 0.5 km. from the discharge point

Date	Temp.	pH	EC	TDS	COD	BOD	DO	Cl^-	CO3''	HCO3'	Calcium
25.08.13	29	7.6	1950	486	49	31	4.8	41.2	0.3	9.8	86
22.09.13	29	7.8	799	589	18	36	4.9	33.0	0.4	6.4	44
26.10.13	29	7.7	678	414	27	27.5	4.8	37.4	0.9	3.2	36
24.11.13	26.8	7.9	317	465	29	27.0	4.3	47.0	0.8	6.7	61
Date	Mg	Na	K	SO4''	TH	Zn	Cu	Fe	Mn	Cobalt	Nickel
25.08.13	28	48	27	390	99	1.96	0.06	0.95	0.30	0.14	0.38
22.09.13	27.2	55	24	129	95	2.92	0.09	1.24	0.21	0.49	0.64
26.10.13	7.2	61	21	276	178	1.96	0.06	0.31	0.14	0.12	0.09
24.11.13	5.2	60	18	165	132	0.99	0.06	1.24	0.24	1.04	0.46

Table 5. Location: Downstream (Spot 4) Near Airani village 5 km from the discharge point

Date	Temp.	pH	EC	TDS	COD	BOD	DO	Cl^-	CO3''	HCO3'	Calcium
25.08.13	29.1	7.9	1546	461	47	27.0	5.6	54.5	0.2	6.8	91.0
22.09.13	29.0	8.3	825	612	14	28.5	5.8	31.1	0.1	3.7	51.4
26.10.13	29.1	7.6	640	220	23	20.1	6.2	54.2	0.5	2.7	41.0
24.11.13	26.4	8.2	402	312	18	31.0	6.6	51.0	0.5	4.2	54.0
Date	Mg	Na	K	SO4''	TH	Zn	Cu	Fe	Mn	Cobalt	Nickel
25.08.13	23.3	47	25	280	65	0.98	0.07	0.86	0.21	0.09	0.40
22.09.13	16.3	54	19	101	89	1.86	0.06	1.36	0.14	0.62	0.32
26.10.13	5.8	31	18	176	92	0.85	0.06	0.27	0.17	0.09	0.08
24.11.13	4.9	26	14	94	122	0.82	0.03	0.94	0.18	0.59	0.24

Table 6. Prescribed legal limits and guidelines

Parameter	WHO	ISI	ICMR
pH	7.0 – 8.5	6.5-8.5	6.5-9.2
EC	1.4 ds /m	1400µs/cm	250
TDS	500	500	1500-3000
BOD	5.0	5.0	---
COD	10.0	10.0	---
DO	5.0	5.0	5.0
Cl'	250	250	1000
Calcium	75-100	45-75	200
Magnesium	30-150	30	50
Sodium	200	200	---
Potassium	1.4	1.4	---
Sulphate	150-250	150-200	400
TH	300	300	600
TA	120	200-600	200-600
Zinc	0.75	---	---
Copper	0.60	---	---
Iron	<1	0.3	---
Manganese	2.0	0.3	---
Nitrate	40-100	40-100	40-100
Fluoride	1.0-1.5	1.0-1.5	1.0-1.5
Color	5 HU	5 HU	5 HU
Odour	Unobjectionable	Unobjectionable	Unobjectionable
Turbidity	5 NTU	5 NTU	5 NTU

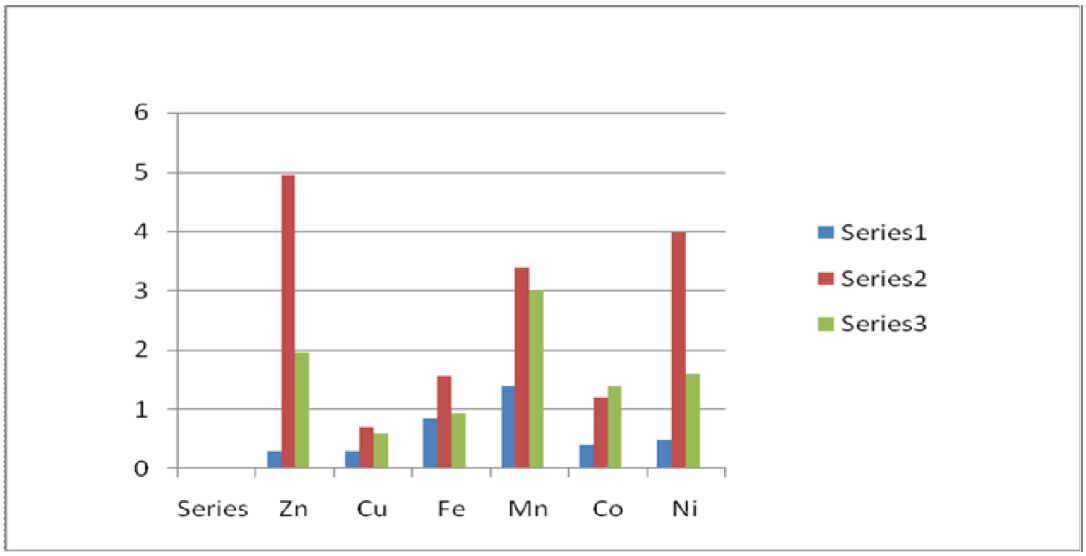

Figure 1. Comparative study of physicochemical parameters at Upstream (Series 1), Discharge point (Series 2) and Downstream (Series 3) water samples

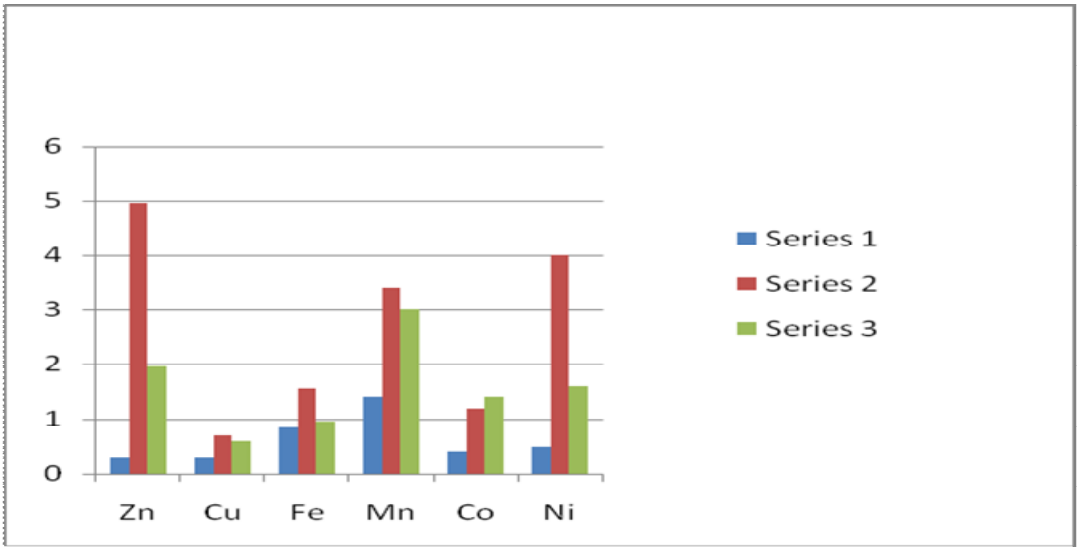

Figure 2. Comparative study of physicochemical parameters at Upstream (Series 1), Discharge point (Series 2) and Downstream (Series 3) water samples

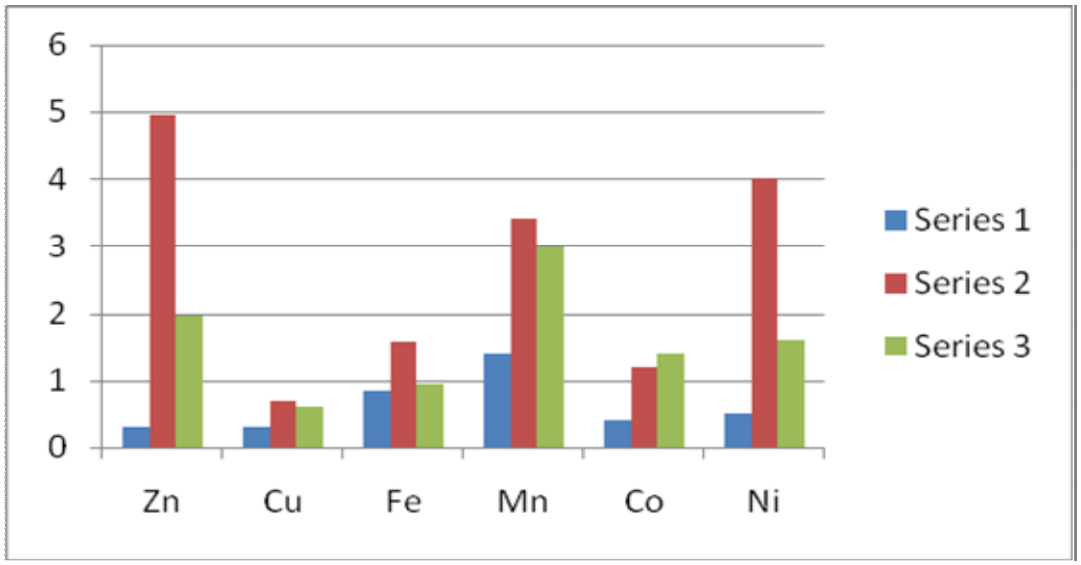

Figure 3. Comparative study of Elements at Upstream (Series 1), Discharge point (Series 2) and Downstream (Series 3) water samples