



Share Your Innovations through JACS Directory

## Journal of Environmental Science and Pollution Research

Visit Journal at <http://www.jacsdirectory.com/jespr>

## Physico-Chemical Parameters, Water Quality Index and Statistical Analysis of Surface Water Contamination by Bleaching and Dyeing Effluents at Kalikapur, West Bengal, India

B.G. Gupta<sup>1</sup>, J.K. Biswas<sup>1,\*</sup>, K.M. Agrawal<sup>2</sup><sup>1</sup>Department of Ecological Studies and International Centre for Ecological Engineering, University of Kalyani, Kalyani – 741 235, West Bengal, India.<sup>2</sup>Department of Environment Management, Indian Institute of Social Welfare and Business Management, Kolkata – 700 073, West Bengal, India.

## ARTICLE DETAILS

## Article history:

Received 29 March 2017

Accepted 06 May 2017

Available online 25 July 2017

## Keywords:

Canal

Bleaching and Dyeing Effluents

Seasonal Variation

Water Quality Index

## ABSTRACT

The present study was conducted to assess the contamination of Chatta Canal due to the discharge of huge quantity of effluent from tiny and small scale (SSI) textile bleaching, dyeing and printing units located at Kalikapur under Maheshtala region (22.29°N, 88.11°E). Apart from effluent the canal also receives household wastewater from neighborhood. The study revealed that the chemical parameters of canal wastewater like chemical oxygen demand (979±459.92 mg/L), biochemical oxygen demand (365 ±174.78 mg/L), suspended solids (110±41.47 mg/L), total dissolve solids (3394±580.94 mg/L), carbonate (867±203.00 mg/L), Chromium (0.061±0.03 mg/L) and Lead 0.103±0.04 mg/L, *E. coli* (380000±213044.59 CFU/100 mL) measured as per APHA (1998) exceeded the maximum permissible limits laid down by WHO (2003). The approach adopted in the present study ascertained the seasonal variation of physico-chemical parameters particularly in summer, rainy and winter seasons and water quality index during those seasons. The study indicated that quality of canal water is very poor for domestic, industrial and agriculture uses. Hence it reflects the usefulness of the analysis of surface water quality assessment. It appears that contaminated surface water requires total treatment to put aside degraded agricultural land, crops, fruits and vegetable required for human consumption.

## 1. Introduction

India being one of the largest manufacturers of cotton, yarn and silk in the world, textile industries are also growing rapidly keeping pace with the increasing demand of modern urban population both to meet the basic need as well as latest fashion. There are six major textile clusters in India. Maheshtala region, West Bengal is one of the oldest textile hubs (800 units) in India and its textile products are supplied to domestic and international markets. Bleaching, dyeing and printing processes of textile industries cause severe pollution and consume enormous quantum of underground and surface water. The discharge of effluent has prolonged harmful effects not only to the aquatic life forms but also destroy the cycle of self-purification characteristic and biological nature of receiving water body [1]. This contaminated and degraded surface water bodies are not useful for agricultural, domestic, industrial, recreation and other purposes [2, 3]. Unclassified chemicals considered harmful and unhealthy [4] are in regular use in the textile hub. The effluent from these small units is characterized by high concentration of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), chloride (Cl), carbonate (CaCO<sub>3</sub>) and heavy metals (Fe, Pb, Cr, Al, Zn, Cd, As, etc.) and carcinogenic dye ingredients [5]. The effects of dyeing effluent on surface water like river and canal have been assessed by several studies [6, 7]. Serious and deleterious biological effects on surface water bodies was also established [8, 9]. Further, in dyeing units, colors are widely used for creating attractive and challenging shades of fabric with the changing need of the fashion oriented society. Presently there is no treatment facilities available with tiny and small scale bleaching, dyeing and printing units associated with textile industries. Consequently, the region suffered from severe pollution of water bodies, aquatic life, agricultural land, crops, vegetables and above all human health at large.

So far, there was no detailed study on the quality and level of contamination of Chatta Canal water and its subsequent effect on land and other water bodies passing through Chatta, Kalikapur (study area) under Maheshtala region. The objective of the study is to establish the pollution

level of the canal water, identification of pollution sources and understanding seasonal variation so that necessary treatment facilities are to be introduced to save the area from dreadful conditions.

Maheshtala (44.77 sqkm) is an urban area having administrative headquarter at Alipore of South 24 parganas district of West Bengal lies between 10.45°N latitude to 75.90°E longitude. Chatta canal running through Chatta and Kalikapur (1.85 sqkm) has been selected for the study. Canal receives maximum effluent from bleaching and dyeing units from the area. Apart from that the canal also receives sewage and household wastewater from different interconnecting drains of the neighborhood. The water carrying capacity of Chatta canal is reducing over the years due to improper cleaning and siltation. The slope of the Chatta canal is generally less than 5%. Two monitoring points (Station A and Station B) was selected in the stretch of Chatta to Kalikapur (500 m apart) for collection of samples. Samples were collected during summer, rainy and winter seasons. The maps of Chatta canal, the state of West Bengal and the district of South 24 Parganas along with location of Maheshtala are given in Figs. 1-3 respectively.



Fig. 1 Map of Chatta Canal

\*Corresponding Author

Email Address: biswajoy2000@yahoo.com (Jayanta Kumar Biswas)

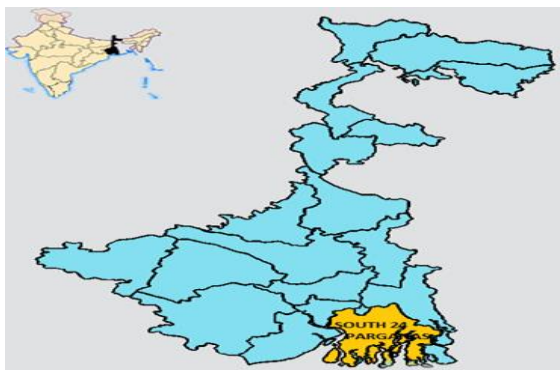


Fig. 2 Map of West Bengal

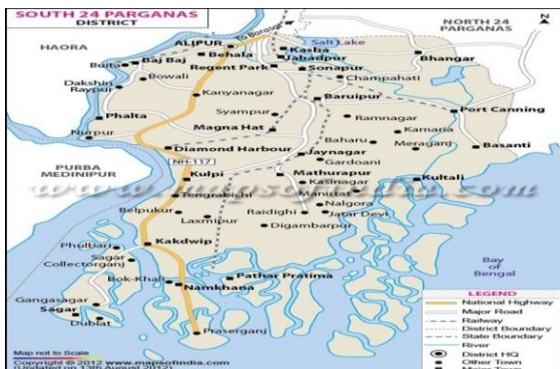


Fig. 3 Map of South 24 Parganas inclusive of Mahestala

2. Experimental Methods

2.1 Collection of Samples

Samples of canal water were collected at regular intervals during 2012-2013 from two monitoring stations (A and B) which were 500 meters apart along the canal stretch. While station A represented the point of direct discharge of raw effluent in the canal and thickly populated area the station B represented the point of normal flowing area of canal with less population (Table 1).

Table 1 Location details of monitoring station

S.No	Station A : Chatta	Station B : Kalikapur
1.	Point of direct discharge of raw effluent	Normal flow area
2.	Latitude: 22.49°N Longitude: 88.24°E	Latitude: 22.41°N Longitude: 88.47°E

2.2 Methodology

Samples were brought to the laboratory and analyzed using the standard method defined and advised by American Public health Association (APHA, 1998). Temperature and pH were measured *in situ* by a mercury thermometer having range from 0 °C-100 °C and with digital portable pH meter, respectively. Total dissolved solids, dissolved oxygen, salinity and turbidity were determined by water analyzer with the help of indicator Systronic-371. Alkalinity was measured by titrametric method using Phenolphthalein indicator. Sodium, potassium and calcium were measured by Flame-photometric method. Nitrate was measured by UV spectra photometric screening method with the help of Zuconyl indicator. Heavy metal samples were acidified and were digested with concentrated HNO<sub>3</sub> acid (0.1%) on a hot plate and analysed after filtration by Whatman filter–paper no. 42. For determination of metal ions atomic absorption spectrophotometer (OMA 300 process analyzer) was used. For analysis of COD, samples were stabilized by acidifying with H<sub>2</sub>SO<sub>4</sub> below 2 and it was measured by dichromate titration method (APHA, 1998) (Table 2).

Table 2 Types of pollutants associated with various types of dyes

Class	Fiber	Nature of pollution
Direct dye	Cotton	Salt, unfixed dyes, copper salt, cationic fixing agents
Reactive dye	Cotton	Salt, unfixed dyes, alkali
Vat dye	Cotton	Alkali, oxidizing agent, reducing agent
Acid dye	Wool	Unfixed dyes, organic dyes
Disperse dyes	Polyester	Carriers, reducing agent, organic acids

3. Results and Discussion

The pH of surface water of canal was found to vary between 7.1 -7.9. The wastewater flowing in the canal was thus alkaline in nature. Highest value of pH (7.9) was observed at Chatta. Alkalinity of surface water is due to excessive use of salt and acids like sodium carbonate, sodium bicarbonate, sodium hydroxide, sodium silicate, sodium peroxide, sodium bisulphate, bleaching powder, sulphuric acid, acetic acid, and tannic acid, detergents in various preparatory and dyeing processes of grey clothes. The water analyzed was characterized by the following: TDS (3394 mg/L), TSS (234 mg/L), carbonate (867 mg/L), BOD (268 mg/L), Chromium (0.06 mg/L) and Lead (0.103 mg/L). The standard tolerance limits for irrigation water are given in Table 3 to assess the status of the water samples the profile of which is presented in Table 4.

Table 3 Tolerance limit of irrigation water quality

Parameter	Tolerance limit ( standard) WHO(2003)
pH	7.5
Nitrate NO <sub>3</sub> (mg/L)	25
Chloride Cal (mg/L)	250
Sulphate SO <sub>4</sub> (mg/L)	200
TDS (mg/L)	500
TSS (mg/L)	500
Chromium Cr (mg/L)	1.0
Lead Pb (mg/L)	5.0
Copper Cu (mg/L)	0.2
Arsenic As (mg/L)	0.05
Zinc Zn ( mg/L)	5.0
E. coli ( CFU/100mL)	5000
BOD ( mg/L)	10
COD ( mg/L)	250

Table 4 Physico-chemical parameters of canal water during summer, rainy and winter season

S. No.	Parameters	Summer Mean Year 2012-13	Rainy Mean Year 2012-13	Winter Mean Year 2012-13
1.	Temp °C	35	31	29
2.	pH	7.16	7.10	7.9
3.	TDS (mg/L)	3394	2240	2700
4.	TSS (mg/L)	234	26	50
5.	BOD <sub>5</sub> (mg/L)	268	28	91
6.	COD (mg/L)	765	98	256
7.	DO (mg/L)	0.00	2.5	0.00
8.	CaCO <sub>3</sub> (mg/L)	666	461	867
9.	Cd (mg/L)	0.014	0.00	0.023
10.	Pb (mg/L)	0.097	0.023	0.103
11.	Cr (mg/L)	0.029	0.03	0.06
12.	As (mg/L)	0.009	0.02	0.037
13	Zn (mg/L)	0.42	0.66	0.00
14.	E-Coli (CFU/100 mL)	380000	10000	12000

The statistical analysis, seasonal variation of water quality and water quality index of canal water are discussed in details.

3.1 Statistical Analysis

Data of physiochemical parameters of canal water samples are presented as mean values and analysed using descriptive analysis (standard deviation) (Table 5). We used standard deviation for describing the spatiotemporal degree of variations of the observed water quality parameters in Chatta canal in different months and seasons (Table 6). The samples are evaluating significant differences among the sites for all water quality variables, data was analyzed using one-way analysis of variance (ANOVA) at 5% level of significance.

Table 5 Descriptive statistics of different parameters of surface water samples

Parameter	Sample S1(sum mer)	Sample S2 (Rainy)	Sample S3 Winter	Descriptive statistics on annual basis		
	Summer	Rainy	Winter	Mean	Standard Deviation	Range
Temp °C	35	31	29	31.666	3.055	29-37
pH	7.16	7.10	7.90	7.386	0.446	7.10-7.9
TDS	3394	2240	2700	2778	580.941	3394
BOD	365	28	91	165.33	174.787	40-365
COD	979	98	256	453.33	459.929	125-979
T S S	110	26	51	63.66	41.477	30-110

CaCO <sub>3</sub>	666	461	867	511	203.00	666-867
DO	0	2.5	0	0.3	0.520	0-0.9
Cd	0.013	0	0.023	0.014	0.012	0-0.023
Pb	0.097	0.02	0.103	0.061	0.042	0.103
Zn	0.284	1.15	0	0.478	0.599	1.15
Cr	0.007	0	0.061	0.022	0.033	0-0.061
As	0.011	0.011	0.037	0.0196	0.015	0.011-0.037
E-coli (CFU/100 mL)	380000	10000	12000	134000	213044.5	10000-380000

All samples showed significant ( $p < 0.05$ ) variations

All parameters are in mg/L except Temp (°C) and pH in no.

**Table 6** Condition of surface water of Chatta canal during summer, rainy and winter seasons

S. No	Para meters	Summer Sample 1	Rainy Sample 2	Winter Sample 3	Summer Condition	Rainy Condition	Winter Condition
1	pH	7.16±0.44	7.11±0.44	7.90±0.44	X	X	X
2	TDS	3394±580.94	2240±580.94	2700±580.94	X	X	X
3	TSS	110 ± 41.47	30 ± 41.47	51 ± 41.47	√	√	√
4	BOD	365 ± 174.78	40 ± 174.78	91 ± 174.78	X	X	X
5	COD	979 ± 459.92	125 ± 459.92	256±45.92	x	x	x
6	DO	0 ± 0.52	0.52	0 ± 0.52	x	x	x
7	CaCo <sub>3</sub>	666±203.00	461±203.00	867±203.00	X	√	X
8	Pb	0.06±0.041	0.02±0.04	0.103±0.04	X	X	X
9	Cd	0.019±0.012	0±0.012	0.023±0.012	√	√	√
10	As	0.011±0.015	0.011±0.015	0.037±0.015	√	√	√
11	Cr	0.007±0.03	0±0.03	0.061±0.03	√	√	√
12	Zn	0.284 ± 0.59	1.15 ± 0.59	0 ± 0.59	X	X	X
13	E-Coli	380000 ± 213044.59	10000 ± 213044.59	12000 ± 213044.59	X	X	X

X=indicate not acceptable for agri-irrigation, √= indicate that acceptable for irrigation

### 3.2 Summer Season

From the above Table 6, it is evident that eight (8) parameters comprising of TDS (3394±580.94), BOD (365±174.78), COD (979±459.92), CaCO<sub>3</sub> (666±453.80), DO (0±0.52), *E. coli* (380000±213044.59), pH (7.16±0.44) (considering + values only), out of 13 parameters examined exceeded its standard permissible limits for irrigation as per WHO (2003). Similarly metal concentration of Cd (0.019±0.012) and Pb (0.06±0.041) have also exceeded above its standard limits of BIS: 10500 for drinking water. The effect of high pH, TDS, BOD, COD, and CaCO<sub>3</sub> and *E. coli* indicates that water quality of Chatta canal are very poor and adversely affects the agricultural production [10]. Higher concentration of TDS is not suitable for irrigation purpose [11]. High level of hardness creates leaching of calcium and magnesium and other polyvalent cations from soil by natural process. Hardness in water may causes heart diseases [12]. High BOD and COD content in water indicate the organic pollution in the canal water due to heavy industrialization particularly discharge of chemicals [13]. Dissolved oxygen level was found very low considering standard limit of WHO (2003). The absence of DO revealed the anaerobic conditions prevailing throughout the canal way. The result is death and decomposition of aquatic life forms and stinking smell in canal water.

High level of heavy metals (Fe and Pb) in water causes gastro-intestinal disorder, neurological problems, paralysis and other carcinogenic effects on human health. It is observed that all the samples have higher *E-coli* counts. Drinking water should be free from bacterial contamination. Irrigation with poor quality surface/ground water influences less germination, root growth, absorption of water and nutrients [14].

### 3.3 Rainy Season

Seven (7) parameters out of 13 parameters of Chatta canal suggests that the canal water is not fit for agricultural irrigation though there was ample flow of fresh water during rainy season. The maximum rainfall occurred during monsoon from July to September of the year.

During Rainy season the Chatta canal drains fresh water upstream which was found suitable for domestic, irrigation and industrial purposes. But as soon as the canal entered into the Chatta industrial area the surface water was mixed with effluents emanated from textile bleaching, dyeing and printing units. The canal water turned turbid and reddish brown to greenish black. The influence of seasonal changes in the chemical parameters were prominent during monsoon season. Due to dilution effect of rain and mixing of fresh water coming from upstream Chatta the concentration of TDS (2270±580.94 mg/L decreases from 3394 mg/L to 2270 mg/L, COD (256±459.92 mg/L) (considering + values only), lowered from 979 mg/L to 256 mg/L, CaCO<sub>3</sub> (461±203.00) declined from 666 mg/L to 461 mg/L, metal concentration also decreases, *E. coli* load decreases from 380000 CFU/100mL to 10000CFU/100 mL, which indicate the qualitative status of canal water improved a bit from very poor to poor quality as per tolerance limits of WHO(2003), BIS(10500)and ICMR(1998) as mentioned in Table 6.

### 3.4 Winter Season

The characteristic of canal water also seasonally changed during winter season. The major parameters like TDS, TSS, BOD, COD, CaCO<sub>3</sub>, BP, Cod, and E-Coli have increased from rainy season to winter season. TDS (2700±580.94) increased from 2240 mg/L to 2700 mg/L, TSS (51 ± 41.47) increased from 30 mg/L to 51 mg/L, BOD(91 ± 174.78) up from 40 mg/L to 91 mg/L, COD (256 ± 459.92) increased from 125 mg/L to 256 mg/L, CaCO<sub>3</sub>(867± 203.00 mg/L) increased from 461 mg/L to 867 mg/L, pH up from 7.16 to 7.9, metal concentration, Pb (0.103±0.04 )increased from 0.023 mg/L to 0.103 mg/L, *E. coli* (12000±213044.59) (considering + values only), increased from 100000 CFU/100 mL to 120000 CFU/100 mL. The above mentioned parameters exceeded the tolerance limits of WHO (2003), BIS (10500) presented in Table 5. Thus the canal water during winter season was also not suitable for domestic, industrial and agric-irrigation purposes.

The results of the physico-chemical parameters of surface water from Chatta canal showed that nine out of 13 parameters crosses the tolerance limit of water required for irrigation purpose. It indicates 66% of the parameter failed to meet the standard limit prescribed by WHO required for agricultural use. The canal water hence, not safe for agriculture even in rainy season and again poor in winter and very poor in summer season [15].

The results of the study conform with the findings for other textile hubs at Vapi, Gujrat, India, at Coimbatore, Tamilnadu, India and at Karur District, India [15-17] where similar approach have been successfully applied to find out the water quality.

Further in this study, the surface water quality has been further verified by Water Quality Index (WQI) formulated on the basis of various physico-chemical parameters to assess the overall quality of water. The physico-chemical parameters include pH, total suspended solids, total dissolved solids, biological oxygen demand, total hardness, chemical oxygen demand, dissolved oxygen and metals like cadmium, lead, chromium, arsenic, zinc and bacteria *E-coli*. 14 parameters have been considered for calculation of water quality index. The WQI has been estimated based on unit's weights recommended by WHO, BIS, ICMR and CCMI for agri-irrigation purpose. The weighted arithmetic index method has been derived [18] for calculation of WQI. The quality rating or sub index ( $a_n$ ) was estimated following the given expression:

$$a_n = 100 [ V_n - V_{i0} ] / [ S_n - V_{i0} ]$$

where,  $a_n$  = Quality rating for the  $n^{\text{th}}$  water quality parameters  
 $V_n$  = Estimated value of the  $n^{\text{th}}$  parameters at a given sample location point  
 $S_n$  = Standard possible value of the  $n^{\text{th}}$  parameter  
 $V_{i0}$  = Ideal value of  $n^{\text{th}}$  parameter in pure water (i.e. 0 for all other parameters except the parameters pH and Dissolved oxygen (7 and 14.6 mg/L respectively.)

Unit weight was calculated by a value inversely proportional to the recommended standard value  $S_{on}$  of the corresponding parameter.

$$W_{in} = K / S_{on}$$

$W_{in}$  = unit weight for the  $n^{\text{th}}$  parameter  
 $S_n$  = Standard value for  $n^{\text{th}}$  parameters  
 $K$  = Constant for proportionality.

The overall water quality Index was calculated by aggregating the quality rating with the unit weight linearly.

$$WQI = \sum q_n W_n / \sum W_n$$

**Table 7** Water Quality Index (WQI) and status of water quality

Water Quality Index Level	Water Quality Status
0--25	Very poor quality
26--50	Poor quality
51--75	Fair quality
76--100	Good quality
>100	Excellent quality water

Source: Canadian council of Ministers of the Environment (CCME) 2001

**Table 8** Calculation of water quality index in summer, rainy and winter season

S. no	Param eters	Sample Mean	Sample Mean	Sample Mean	Unit Weight (Win)	An sum mer	Wn qn summ er	Qn rai ny	Wnqn Rainy wint er	Qn wint er	Wnqn winter	
1	pH	7.16	7.10	7.9	0.133	2.13	0.28	1.33	0.17	12	1.6	
2	TDS	3394	2240	2700	0.002	485	0.97	320	0.64	386	0.77	
3	TSS	234	26	50	0.003	23.3	0.07	23.4	0.07	50	0.15	
4	CaCO <sub>3</sub>	666	461	863	0.015	133	2.00	92.2	1.38	172	2.58	
5	BOD	268	28	91	0.167	268	44.7	280	46.7	910	152	
6	DO	0	2.5	0.00	0.372	243	90.3	201	74.7	243	90	
7	E coli	380000	10000	12000	0.000	7600	0.00	200	0.00	240	0.0	
8	COD	765	98	256	0.100	300	30.0	39.2	3.92	10	10	
9	Cd	0.014	0.00	0.023	0.098	140	13.7	0.00	0.00	230	23	
10	Pb	0.097	0.023	0.103	100.0	1.94	194	0.46	46.0	2.6	260	
11	Cr	0.029	0.03	0.06	20.00	29	580	30	600	60	1200	
12	Zn	0.42	0.66	0.00	0.333	8.4	2.80	13.2	4.4	0.00	0.00	
13	As	0.009	0.02	0.037	100.0	18	1800	40.0	4000	60	6000	
						221.2	9252	2759	1241	4778	2469	7740
Water Quality Index (Summer) = $\sum q_n W_n / \sum W_n = 12.4$						$(\sum W_n = 221.2, \sum q_n = 9252, \sum q_n W_n = 2759)$						
Water Quality Index (Rainy) = $\sum q_n W_n / \sum W_n = 21.6$						$(\sum W_n = 221.2, \sum q_n = 1241, \sum q_n W_n = 4778)$						
Water Quality Index (Winter) = $\sum q_n W_n / \sum W_n = 35.0$						$(\sum W_n = 221.2, \sum q_n = 2469, \sum q_n W_n = 7740)$						

Water quality Index calculated as per Canadian Environmental Method (CCME) based on 13 parameters

Water quality Index of the Chatta canal has been derived from various important physico-chemical parameters as mentioned in Tables 7 and 8. The season wise WQI for summer, rainy and winter are also given in this tables. It is observed that the water quality index in summer is 12.4, in rainy season 22.6 and in winter season is 35.0 which indicates very poor quality of water in summer and poor quality water in rainy and winter season as per (CCME 2001) scale. The water quality study clearly shows that the canal water is eutrophic and unsuitable for human consumption, industrial use as well as agri-irrigation. Hence it appears, the observations made by other researchers in their studies [18-20] are in conformity with the observation made in this study.

#### 4. Conclusion

Both the results obtained from physico-chemical parameters and water quality index indicate that the canal water running through Chatta, Kalikapur, Mahispota of Maheshtala region reflect very poor quality in summer and poor in rainy and winter season. The canal water is not at all suitable for drinking, domestic, and industrial and agriculture purpose. The novelty of the work is that the study corroborated similar quality implications with physic-chemical parameters and WQI for three season

while compared with standards. This observation is also supported by first hand physical verification done during collection of samples while there was no agricultural production of crops in the vicinity and the neighborhood villages along the textile bleaching and dyeing cluster except a few species of long grasses.

The time is long overdue to take a hard look at this undesirable and non-planned growth of these bleaching and dyeing units and it is need of the time to take some preventive, restorative and rehabilitative measures including adoption of adequate treatment processes to prevent further degradation of agricultural land, crops, food chain, human health and aquatic life as a whole.

#### References

- [1] A.Y. Sangodoin, Ground water and surface water pollution by open refuse dump in Ibadan Nigeria, J. Discovery Innovation 3(1) (1991) 24-31,
- [2] V. Simenonov, P. Simenonov, C. Samara, G. Zachariadis, D. Vousta, et al, The assessment of the surface water quality in Northern Greece, Water Res. 37(17) (2003) 4119-4124.
- [3] H.P. Jarvie, B.A. Whitton, C. Neal, Nitrogen and phosphorous in east coast British rivers: specification, Sources, and biological significant, Sci. Total Environ. 210-211 (1998) 79-109.
- [4] Ravi Kumar, P.K. Dutta, Are textile finishing the Environment? , Ind. J. Environ. Protection 16 (7) (1996) 499-501.
- [5] G. Tchobanoglous, F.I. Burton, Waste water engineering: treatment, disposal and reuse, TATA- Mac-Graw Hill Publishing India Limited, New Delhi, 1995.
- [6] R.B. Khadka, A.B. Khanal, Environmental management plan for melamchi water supply project, Nepal, Environ. Monitor Assess. 146(1-3) (2008) 225-234.
- [7] M. Vega, R. Pardo, E. Barrado, L. Deban, Assessment of seasonal and polluting effects on the quality of river water exploratory data analysis, Water Res. 32(12) (1998) 3581-3592.
- [8] K.O. Olayinka, B.I. Alo, Studies on industrial pollution in Nigeria, the effect of textile effluents on the quality of ground water in some parts of Lagos, Nigerian J. Health Bio Med. Sci. 3(1) (2004) 344-357.
- [9] A.H. Mthethia, A. Munyenembe, W. Jere, E. Nyali, Efficiency of oxidation ponds in waste water treatment, Int. J. Environ. Res. 2(2) (2008) 149-152.
- [10] D. Balachandra, Sundarraj, P.M.K. Ruthaavel, K. Kumarswamy, An investigation of ground water quality and its suitability to irrigated agriculture in Coimbatore district, Tamilnadu, India, A GIS approach, Int. J. Environ. Sci. 1(2) (2010) 176-190.
- [11] Masood Alam, Anwar Ahmed, Water quality in and around industrialized city of Delhi East and Sahibabad, Ind. J. Environ. Protection 22(8) (2002) 900-904.
- [12] C.K. Shastry, A. Aboo, H.L. Bhatia, A.V. Rao, Pollution of upper lake and its effect on Bhopal water supply, J. Environ. Health 12 (1970) 218-238.
- [13] A. Solaimalai, R. Saravanakumar, Assessment of irrigation water qualities, In Water pollution assessment and management, Daya publishing House, New Delhi, 2004, pp. 389-395.
- [14] D. Balachandra, Sundarraj, P.M.K. Ruthaavel, K. Kumarswamy, An investigation of ground water quality and its suitability to irrigated agriculture in Coimbatore district, Tamilnadu, India, A GIS approach, Int. J. Environ. Sci. 1(2) (2010) 176-190.
- [15] V. Kannan, R. Ramesh, C. Sashikumar, Study on ground water characteristic and the effects of discharged effluents from textile units at Karur District, India, J. Environ. Bio. 26 (2) (2005) 269-272.
- [16] V. Kannan, Tharamani, Assessment of industrial ground water pollution potential from correlation of parametric ratio-Dye industry, Ind. J. Environ. Protect. 13(5) (1993) 346-348.
- [17] R.M. Brown, N.J. Mc cleiland, R.A. Deiniger, M.F.A.O. Connor, Water quality index-crossing the physical barrier (S.H. Jenkis Ed.), Proc. Int. Conf. Water Poll. Res. Jerusalem 6 (1972) 787-797.
- [18] N.R. Reddy, S.K. Sathe, D.K. Salunkhe, Phytates in legumes and cereals, Adv. Food Res. 28 (1982) 1-92.
- [19] A.V. Navarro, M.Y. Ramirez, S.M.S. Salvador, J.M. Gallardo, Determination of waste water LC 50 of the different process stage of the textile Industry, Ecotoxicology Environ. Safety 48 (2001) 56-61.
- [20] U. Sankar, Economic analysis of environment problem in tanneries and bleaching and dyeing industries, Allied Publishers, New Delhi, India, 2000.