academicJournals

Vol. 7(2), pp. 23-28, February, 2015
DOI: 10.5897/JENE2015. 0495
Article Number: 6072CF550975
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

Effects of municipal and industrial discharges on the quality of Beressa river water, Debre Berhan, Ethiopia

Haymanot Awgchew[1]*, Heluf Gebrekidan[2] and Adamu Molla[3]

[1]Department of Plant Science, College of Agriculture and Environmental Science, Debre Berhan University, P.O. Box: 445 Debre Berhan, Ethiopia.
[2]Department of Natural Resources Management and Environmental Sciences, College of Agriculture, Haramaya University, P.O. Box: 138, Dire Dawa, Ethiopia.
[3]Crop research directorate, Debre Berhan Agricultural Research Centre, P.O. Box: 112, Debre Berhan, Ethiopia.

Received 1 January, 2015; Accepted 22 January, 2015

The problem of environmental pollution is not simple and easy to ignore because it affects the survival and normal functioning of an ecosystem by changing the overall healthy interaction between its components and after once it occurs, will be difficult to control. Fortunately, in the town of Debre Berhan (Tebasie), it is a common phenomenon due to the discharge of untreated liquid and solid wastes from industrial and municipal activities. Thus, this study was conducted to determine the status of Beressa River and to reveal the effects of industrial and municipal discharges on the water quality of the river for irrigation and other domestic uses. After selecting six different sampling sites depending on the suspected and identified sources of pollution, the river water was analyzed for different parameters like temperature, pH, electrical conductivity (EC), oxygen demand [biological oxygen demands (BOD) and chemical oxygen demand (COD)], total suspended solids (TSS), total dissolved solids (TDS), PO_4^{3-}, SO_4^{2-}, HCO_3^-, NH_4^+, NO_3^-, Cl^- B, basic cations (Na, K, Ca and Mg), heavy metals (Cr, Pd, Cd, Ni, Hg and As) and micro nutrients (Fe, Mn, Cu and Zn). The water had no problem related to temperature, pH and EC. However, the COD, BOD, PO_4^{3-}, TSS, TDS, Pb and Hg contents at different site were above their respected maximum permissible limit but the rest detections were below the concerned allowable value while requiring an extra attention for restoring the quality with the control or avoidance of further deteriorations.

Key words: heavy metals, oxygen demand, pollution, river water quality.

INTRODUCTION

Environmental pollution is any change which affects the integrity of an ecosystem (Ekuri and Eze, 1999). Most of the time, the changes are caused by the action of human being like industrialization (Han et al., 2002), urbanization, construction and transportation (Jande, 2005) and poor agricultural and land use management practices (Novotny and Olem, 1994). According to Katyal and Satake (2006), the changes affect human being directly or indirectly through determining the supply of water, agricultural and other biological inputs, physical objects/ possession and

*Corresponding author. E-mail: haymiti02@gmail.com.

opportunity to appreciate nature/ recreation.

Most of the time, water bodies are susceptible for pollution due to rapid population growth and improper waste disposal and management practices. For example, the Gombak River in Kuala Lumpur, Malaysia is under influence due to population status of the area (Zubaidah et al., 2011). Untreated domestic and industrial wastes have an effect on the water quality of the Nhue River in Hanoi, Vietnam (Kikuchi et al., 2009), the Cuvum and Adyar Rivers in Chennai, India (Gowri and Ramachandran, 2001), the Ibese and Ikopoba Rivers in Nigeria (Awomeso et al., 2009) and the Modjo, Kebena, Akaki, Chacha, Megecha, Wabe, Ghibe, Dabena and Sor Rivers in Ethiopia (Baye, 2006). And according to Negash et al. (2011), the quality of the Beressa river water for irrigation and other domestic uses is under problem because of improper waste disposal and management.

In the town of Debre Berhan (Tebasie), environmental pollution is a common phenomenon due to the absence of waste disposal access, lack of awareness and some control measures. However, the problem of environmental pollution is not simple and ignored for the reasons that it alters the survival and well-functioning of a given ecosystem and once it happens, it is difficult to control. Therefore, this study was conducted in order to determine the status of Beressa River and to reveal the effects of industrial and municipal discharges on the quality of the Beressa River water.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Tebasie sub-town of Debre Berhan town which is located at 09° 35' 45'' to 09° 36' 45'' north latitude and from 39° 29' 40'' to 39° 31' 30'' east longitude and found at 125 km north east of Addis Ababa with an elevation ranging between 2800 and 2845 meters above sea level. The twenty seven (27) years (1985-2011) data obtained from the Ethiopian National Meteorological Agency indicates that, the area receives a mean annual rainfall of 927.10 mm and characterized by an unimodal rainfall pattern with a maximum (293.02 mm) and minimum (4.72 mm) peaks in August and December, respectively. The mean monthly maximum and minimum temperature ranged from 18.3 to 21.8 °C and from 2.4 to 8.9 °C, respectively.

Site selection, sample collection and preparation

In this study, six sites (Site 1- found around Eyerusalem Vegetable Farm, Site 2- found around the Debre Berhan Blanket Factory (DBBF) and the Ask Flower Farm Private Limited Company (AFFPLC), Site 3- at the Debre Berhan University's (DBU) waste disposal area, Site 4- found at different household waste disposal area, Site 5- found around the Terra Vegetable Farm and Site 6- found around the Debre Berhan Tanning and Leather Finishing Factory (DBTLFF)) were taken as water sampling area based on the suspected and observed sources of pollution.

Since the aim of this study was concerned with the detection of the water quality for irrigation and domestic uses, the water samples were collected once from each site in the morning (9 to 11 am) by the end of February 2013 (the maximum expected utilization and pollution time) using a plastic jar by considering its depth (about 50 cm), relative movement speed (being steady and moving), turbidity (dilution) status and distance from the land (about 2 m for the easy of irrigation accessibility and domestic uses). There were up to ten sub samples at each experimental site that were put and stirred in a 20 L plastic bucket to make a representative composite sample for each sites and were poured into a two litter plastic bottle. Generally, before laboratory analysis the samples were kept in refrigerator until the collection of all samples have been conducted within two successive days.

Laboratory analysis

The temperature and pH of the water samples were determined by using a hand-held thermometer and pH meter directly from the samples being prepared. With a conductivity meter, the electrical conductivity and total dissolved solids (TDS) were measured. The bicarbonate content was estimated by the acidimetric/ HCl titration method (USSLS, 1954). The boron content was determined using Azometiene H method (Kluczka et al., 2007) and the chloride was determined by Silver nitrate method (Mohr's argentometric method) using potassium chromate as the indicator. The water samples were analysed for soluble cations at which the Na and K contents were determined by flame photometer while the Ca and Mg were determined by atomic absorption spectrophotometer (AAS). The biochemical oxygen demand (BOD) was measured according to the standard methods (APHA, 2005) and chemical oxygen demand (COD), ammonia, nitrate, phosphate and total suspended solids (TSS) contents were measured by using spectrophotometer (Hach, 1997). Moreover, the water samples were analyzed for their heavy metals (Cd, Cr, Pd, Ni, As and Hg) and micronutrients (Fe, Cu, Zn and Mn) content by using AAS according to standard methods (APHA, 2005).

RESULTS AND DISCUSSION

The temperature of the Beressa River water at site 2 was highest among the other sites (Table 1). However, all were below the maximum permissible limit of 40°C (EEPA, 2003) which affect the growth and survival of normal aquatic biota and were found to meet the WHO permissible range (12 to 25°C) for healthy functioning of aquatic ecosystem. This means, all the recorded water temperature values are not likely to affect the quality of the water for sustaining life. The raised temperature at site 1 might be due to the machinery cooling activity of the DBBF. Temperature has an effect on important water properties like specific conductivity and solubility of dissolved solutes and gases (oxygen and carbon dioxide) and generally, warmer water holds less available/ free oxygen which results in respiration problem on aquatic organisms (Malina, 1996).

The pH values of the Beressa River water ranged between 7.24 and 7.42 (Table 1) which was in the permissible range of 6 to 9 (EEPA, 2003) for normal activity of the aquatic biota. Generally, high pH value could cause toxicity of some pollutants in the water body. For example, if the pH of water goes beyond 8.5, ammonia becomes more toxic and can adversely harm

Table 1. The mean temperature and chemical compositions of the River water at different sites.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Temperature (°C)	19.50	24.50	21.00	19.50	18.00	21.50
pH	7.38	7.31	7. 42	7.33	7.24	7.32
EC (µS cm^{-1})	181.19	197.59	198.71	198.33	196.84	193.28
COD (mg L^{-1})	20.18	75.23	164.00	153.67	52.26	86.00
BOD_5 at 20°C (mg L^{-1})	6.95	22.06	107.00	98.11	13.07	28.00
TSS (mg L^{-1})	46.50	40.50	46.50	45.50	57.50	39.50
TDS (mg L^{-1})	170.43	171.52	170.47	194.18	198.46	167.11
Phosphate (mg L^{-1})	9.20	10.01	15.71	8.06	10.31	20.04
Sulphate (mg L^{-1})	10.23	13.78	19.91	15.19	18.13	21.11
Bicarbonate (mg L^{-1})	116.23	127.55	132.27	128.68	127.89	125.46
Ammonia (mg L^{-1})	0.02	1.03	1.12	0.53	0.54	0.96
Nitrate (mg L^{-1})	0.04	0.19	0.43	0.34	0.43	0.48
Chloride (mg L^{-1})	9.78	12.66	16.22	15.26	18.15	13.51
Boron (mg L^{-1})	0.01	0.04	0.02	0.03	0.01	0.04
Sodium (mg L^{-1})	9.45	10.89	10.12	12.55	9.68	14.56
Potassium (mg L^{-1})	4.17	3.78	4.36	4.83	4.67	4.87
Calcium (mg L^{-1})	37.17	33.53	42.14	35.05	46.46	45.81
Magnesium (mg L^{-1})	5.70	5.90	6.32	4.90	4.41	7.50
Iron (mg L^{-1})	ND	0.026	0.010	0.004	ND	0.002
Manganese (mg L^{-1})	ND	ND	0.001	0.001	ND	ND
Copper (mg L^{-1})	0.001	0.013	ND	0.006	0.003	ND
Zinc (mg L^{-1})	0.001	0.006	ND	0.002	0.014	ND
Cadmium (mg L^{-1})	ND	0.026	0.022	0.013	ND	0.011
Chromium (mg L^{-1})	0.004	0.021	0.013	0.016	0.018	0.025
Lead (mg L^{-1})	0.002	0.005	0.007	0.009	0.003	0.006
Nickel (mg L^{-1})	ND	0.001	0.015	0.021	0.021	ND
Arsenic (mg L^{-1})	0.001	0.005	0.011	0.011	0.024	0.023
Mercury (mg L^{-1})	ND	0.001	0.001	0.001	0.001	ND

ND = Not detected.

the normal aquatic biota (Kallqvist and Svensson, 2002). Most of the living aquatic organisms are sensitive to pH which reduces or changes their abundance as it goes outside the tolerable limit (Novotny and Olem, 1994) and according to Kimmel (1983), it can have a direct effect on the physiology of organisms which results in detrimental biological community dominated by few tolerant taxa.

The electrical conductivity (EC) values of the Beressa River water ranged from 181.19 µS cm^{-1} at site 1 to 198.71 µS cm^{-1} at site 3 (Table 1) which was about five times below the maximum permissible limit of 1000 µS cm^{-1} (EEPA, 2003) beyond which the activity and growth of living organisms in the water body is limited due to osmotic effect. This implies that the River had no problem of salinity which affects its use basically for crop production.

The maximum and minimum biological oxygen demands (BOD) were found in the water of sites 3 and 4, respecttively (Table 1) and were above the maximum permissible limit of 50 mg L^{-1} (EEPA, 2003) at which the decomposition of organic pollutants in the water bodies is affected due to the shortage of dissolved oxygen (DO). Apparently, the sources of BOD in the water were biodegradable organic substances contained in the discharged effluents of the DBU, DBTLFF, DBBF and households. The water at site 1 was the lowest in its chemical oxygen demand (COD) content while site 3 had the highest value and followed by site 4 (Table 1) which were above the maximum permissible limit of 150 mg L^{-1} (EEPA, 2003) which implies that more DO is required to decompose the organic pollutants in the water. According to Negash et al. (2011), the amount of COD in the Beressa River water was above the permissible limit of EEPA because of the effluents of DBU, DBTLFF, DBBF and municipal waste water discharged without treatment.

Generally, the highest and lowest contents of total suspended solids (TSS) were found in the water of sites 5 and 6, respectively (Table 1). However, all the sites had a TSS values above the maximum permissible limit of 30 mg L^{-1} (EEPA, 2003) beyond which the normal activity of aquatic organism is affected due to the reduced amount of light penetrating into the water and both the point and non-point sources might be a reason for the high TSS content in the Beressa River water. In the water of sites 5 and 6, the highest and lowest total dissolved solids (TDS) contents were found, respectively (Table) and all were about a fold higher than the maximum permissible limit value of 80 mg L^{-1} (EEPA, 2003) at which the concentration of heavy metals is increased to undesirable level. According to Negash et al. (2011), influx of untreated effluent/waste from different institutions, factories, municipal and poor land use practice in the watershed was blamed as causes for the raised TDS content.

The amounts phosphate in the water of sites 1 and 4 was relatively lower than the others which were above the maximum permissible limit of 10 mg L^{-1} (EEPA, 2003) at which the growth of aquatic plants is enhanced and cause shortage of DO. Negash et al. (2011) have also indicated that phosphate was among the pollutants in the Beressa River water due to untreated municipal effluents, domestic sewages, discharges of the DBU, tannery and poorly managed agricultural lands. Generally, waste water and domestic phosphate based detergents, human and animal wastes, decomposing plants and runoff from fertilized croplands are the main sources of phosphate which can allow the growth of aquatic plants and change the types and abundance of organisms in a stream (Morrison et al., 2001). The content of sulphate in the river water was minimum at site 1 and maximum at site 6 with an increasing manner (Table 1). However, all the detected amounts were below the maximum permissible limit of 200 mg L^{-1} (EEPA, 2003) beyond which the water becomes unsafe for drinking due to the interference in enzymatic activity. According to Negash et al. (2011), the river was free from the risk of sulphate pollution. The lowest and highest bicarbonate contents were 116.23 and 132.27 mg L^{-1} in the water of sites 1 and 3, respectively (Table 1) and were found to be below the maximum permissible limit of 200 mg L^{-1} (EEPA, 2003) beyond which precipitation of Ca and Mg in the soil solution occurs up on irrigation. Thus, the Beressa River water could not be an immediate source of bicarbonate pollution on the soils.

The maximum and minimum amounts of ammonia were recorded from the water at sites 3 and 1, respecttively (Table 1) but all were below the maximum permissible limit of 30 mg L^{-1} (EEPA, 2003) beyond which the growth and survival of most aquatic organisms is affected. In this situation, the possible sources might be the discharge of human and animal wastes, industrial and domestic waste waters and decayed organic matter. Moreover, the other sources of ammonia in surface water are runoff from fertilized lands, leaching from septic tanks, sewage and erosion of natural deposits (Kafia et al., 2009). Sites 3 and 5 had similar content of nitrate (Table 1) with the lowest and highest amounts at sites 1 and 6, respectively. However, all were below the maximum permissible limit of 50 mg L^{-1} (EEPA, 2003) at which the growth of aquatic plants is stimulated and cause water quality reduction. In water bodies, nitrate could occur as a result of the deamination of ammonium nitrogen from nitrogenous materials and/or raw wastes that can be oxidized to nitrate by the action of microbiological agents (Morrison et al., 2001).

The maximum and minimum amounts of Na were recorded in the water of sites 1 and 5, respectively (Table 1). However, all the contents were below the maximum permissible limit of 200 mg L^{-1} (EEPA, 2003) at which the quality of water for irrigation and domestic uses is affected due to salinity, sodicity and specific ion toxicity problems. The lowest and highest concentrations of K were recorded in the water of sites 2 and 6, respectively (Table 1) and all the contents were below the maximum permissible limit of 5 mg L^{-1} (EEPA, 2003) beyond which the growth and metabolism of aquatic organisms is affected. The amounts of Ca and Mg ranged from 33.17 to 46.46 mg L^{-1} in the water of sites 2 and 3 and from 4.41 to 7.5 mg L^{-1} in the water of sites 5 and 6, respecttively (Table 1). However, both Ca and Mg were below the maximum permissible limit of 100 mg L^{-1} (EEPA, 2003) which causes reduction of water quality for domestic uses due to hardness (reduced ion exchange). Generally, the amount basic cations in the water of site 6 was higher which could be due to the use of salts (NaCl and KCl) and other preservatives containing Na and K for soaking and curing purpose (Cassano et al., 2001) and the use of Ca and Mg containing limes for conditioning of raw hides and skins (Ramasami and Prasad, 1991).

The lowest and highest contents of Cl^- were recorded in the water of sites 1 and 6 (Table 1) but all were below the maximum permissible limit of 250 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of organisms is affected. The observed amounts could come from the sewages containing chloride. The contents of boron ranged from 0.01 mg L^{-1} at sites 1 and 5 to 0.04 mg L^{-1} at sites 2 and 6 (Table 1). But, the contents in all sites were below the maximum permissible limit of 2 mg L^{-1} (EEPA, 2003) beyond which some deleterious effects are occur on certain agricultural crops and aquatic organisms. Since it is used in cleaning compounds and alloys, the observed concentration especially at sites 2 and 6 might come from the effluents from the DBBF and DBTLFF.

Copper was not detected in the water of sites 3 and 6 but it was highest in the water of site 2 (Table 1) and in all cases the concentration was below the maximum permissible limit of 2 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. According to Shanmugam et al. (2006), the abrupt increase in Cu concentration in water bodies is due to surface runoff and pipeline discharges which could be considered as sources for the case of the Beressa River.

Iron was not detected in the water of sites 1 and 5 while its maximum presence was found in the water of site 2 (Table 1) but in all cases it was below the maximum permissible limit of 1 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. Manganese was detected only in the water of sites 3 and 4 (Table 1) and it was below the maximum permissible limit of 5 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. The contents of zinc in the Beressa River were below the maximum permissible limit of 5 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. Generally, it was not detected in the water of sites 3 and 6 but was the highest in the water at site 5 (Table 1).

Cadmium was not detected in the water of sites 1 and 6 but was the highest in the water of site 2 (Table 1) and the Cr concentrations were minimum and maximum in the water of sites 1 and 6, respectively (Table 1). However, the concentrations of Cd and Cr in the water of all sites were below the maximum permissible limit of 0.05 mg L^{-1} (EEPA, 2003). All the contents of Pb in the water were above the maximum permissible limit of 0.001 mg L^{-1} (EEPA, 2003). But, the lowest and highest values were recorded in the water of sites 1 and 4, respectively (Table 1). Nickel was not detected in the water of sites 1 and 6 (Table 1) and it was below the maximum permissible limit of 0.02 mg L^{-1} (EEPA, 2003) in the remaining sites. The amount of As in the water of all sites was below the standard limit value of 0.01 mg L^{-1} (EEPA, 2003). The water at sites 6 and 1 had the maximum and minimum amounts of As, respectively. Mercury was not detected in the water of sites 1 and 6 and except the water of these sites, all had a similar value of 0.001 mg L^{-1} (Table 1) that was equal to the standard limit value of 0.001 mg L^{-1} (EEPA, 2003). Similar study by Negash et al. (2011) had shown the concentration of heavy metals like Cd, Cr, Pb, Ni, As and Hg in the water of the Beressa River were above the standard limit value due to untreated industrial and municipal wastes, fuels and gasoline from motor vehicles, fertilizer (Pb, Cd, As), pesticides (Pb, As, Hg), sewage sludge (Cd, Pb, Se), irrigation (Cd, Pb, Se) and manure (As, Se).

Conclusion

The highest and the lowest temperatures of the Beressa River water were recorded at sites 2 and 5, respectively, and the pH values ranged between 7.24 and 7.42. The EC was minimum at site 1 and was maximum at site 3 and the COD content at site 1 was the least and at site 6 was the highest while the BOD content at site 1 was the lowest and at site 3 was the highest. Generally, the maximum and minimum TSS and TDS were recorded at site 5 and 6, respectively. Sites 4 and 6 were the lowest and highest in their phosphate contents. In the river water, sulphate, bicarbonate, ammonia and nitrate ranged between 10.23 and 21.11, 116.23 and 132.27, 0.02 and 1.12 and 0.04 and 0.48 mg L^{-1}, respectively, and at sites 1 and 5 the minimum and maximum amount of chloride and minimum amount of boron were analyzed. Moreover, the concentrations of Na, K and Mg were higher at site 6 while Ca was highest at site 5. There was no detection of Fe at sites 1 and 5, Mn at sites 1, 2, 5 and 6, Cu and Zn at sites 3 and 6, Cd at sites 1 and 5 and Ni and Hg at sites 1 and 6. However, Cr was lowest and highest at site 1 and 6, respectively while Pb was minimum and maximum at sites 1 and 4, respectively.

Eventually, the Beressa River water had no problem related to temperature, pH and EC and generally the water of all sites were below the maximum permissible limit in their HCO_3^-, SO_4^{2-}, NH_4^+, NO_3^-, Na, K, Ca, Mg, Cl-, B, Cu, Fe, Mn, Zn and heavy metals (Cd, Cr, Ni and As) contents. However, extra attention is required because they were on the way to deteriorate the water quality in the near future. The amounts of COD and BOD in the water of sites 3 and 4, PO_4^{3-} in the water of sites except 1 and 4, TSS, TDS and Pb in the water of all sites were above their respective maximum permissible limits and Hg in the water of sites except 1 and 6 was equal to its maximum permissible limit. That means all of these excessive characters need an immediate remediation measure.

Conflict of interests

The authors did not declare any conflict of interest.

ACKNOWLEDGMENTS

The authors would like to greatly acknowledge the School of Graduate Studies (Haramaya University) and Debre Berhan University (Ministry of Education) for the overall assistances made so far and they are obliged to extend their deepest gratitude to all individuals and institutions who in one way or another contributed for the betterment of the work starting from the very beginning to the end.

REFERENCES

American Public Health Association (APHA) (2005). Standard methods for the examination of Water and Wastewater, American Public Health Association, Washington, DC.

Awomeso JA, Ufoegbune GC, Oluwasanya GO, Ademola-Aremu OO (2009). Impact of industrial effluents on water, soils and plants in the Alakia industrial area of Ibadan, South West Nigeria. Toxicol. Environ. Chem. 91(1): 5-15.

Baye S (2006). Assessment of Benthic-Macro invertebrate structures in relation to environmental degradation in some Ethiopian Rivers. MSc thesis, School of Graduate Studies, Addis Ababa University.

Cassano A, Molinari A, Romano M, Drioli E (2001). Treatment of aqueous effluents of the leather industry by membrane processes. A Review. J. Membr. Sci. 181: 111-126.

Ekuri P, Eze EB (1999). Teaching Environmental Pollution in Primary/secondary schools. In: Proceedings of the Orientation Workshop for Teachers on the Implementation of the National Environmental Education Curricula. Ogoja, Nigeria. October, 1999.

Ethiopian Environmental Protection Authority (EEPA) (2003). Provisional standards for environmental pollution control in Ethiopia. Prepared under the Ecologically Sustainable Industrial Development (ESID) project. Addis Ababa, Ethiopia.

Gowri VS, Ramachandran S (2001). Coastal pollution of Chennai city, Coastal geomorphology of India. Institute of Ocean Management, Anna University, Chennai, India.

Hach (1997). Hach Water Analysis Handbook 3rd ed. Hach Company, Loveland, Colorado, USA. 1250p.

Han FX, Banin A, Su Y, Monts DL, Plodinec MJ, Kingery WL, Triplett GE (2002). Industrial age anthropogenic inputs of heavy metals into the pedosphere. Nature- wissenschaften 89:497-504.

Jande GG (2005). Legal Mechanisms for the control of Pollution on the sea. Afr. J. Environ. Law Dev. Stud. 1: 1-13.

Kafia MS, Slaiman GM, Nazanin MS (2009). Physical and Chemical Status of Drinking Water from Water Treatment Plants on Greater ZabRiver. J. Appl. Sci. Environ. Manage. 13(3):89-92.

Kallqvist T, Svensson A (2002). Assessment of ammonia toxicity in tests with the microalga, Nephroselmispyriformis, Chlorophyta. Water Res. 37:477-484.

Katyal T and Satake T (2006). Environmental Pollution. Anmol publication, New Delhi, India. 174p.

Kikuchi T, Furuichi T, Huynh T, Tanaka S (2009). Assessment of heavy metal pollution in River water of Hanoi, Vietnam, using multivariate analyses. Bull. Environ. Contam. Toxicol. 83:575-582.

Kimmel WG (1983). The Impact of Acid Mine Drainage on the Stream Ecosystem. In: S.K. Majumdar and W.W. Miller (eds.). Pennsylvania Coal: Resources, Technology and Utilization, the Pennsylvania Academy of Science Publication. pp. 424-437.

Kluczka J, Ciba J, Trojanowska J, Zolotajkin M, Turken M, Dydo P (2007). Removal of boron dissolved in water. Am. Inst. Chem. Eng. Environ. Prog. 26 (1):71-77.

Malina JF (1996). Water quality. In: L.W. Mays (ed.). Water Resources Hand Book, McGraw-Hill, New York, USA. pp. 60-62.

Morrison G, Fatoki OS, Persson L, Ekberg A (2001). Assessment of the impact of point source pollution from the Keiskammahoek sewage treatment plant on the KeiskammaRiver: pH, EC, COD and nutrients. Water S. A. 27(4):475-480.

Negash T, Bzuayehu T, Agete J (2011). Investigation of pollutants and its mitigation measure to conserve the potential of Beressa River. In: Debre Berhan University research and community service. Debre Berhan, Ethiopia. Research proceeding II, volume 2, no. 1. pp. 30-49.

Novotny V, Olem H (1994). Water Quality: Prevention, identification and management of diffuse pollution. Van Nostrand Reinhold, New York. USA. 1054p.

Ramasami TS, Prasad BG (1991). Environmental aspects of leather processing. Proceedings of the LEXPO–XV, Calcutta, India, 43p.

Shanmugam P, Neelamani S, Ahn YH Philip L and Hong GH (2006). Assessment of the levels of coastal marine pollution of Chennai city, Southern India. Springer Science. Business Media B. V.

United States Salinity Laboratory Staff (USSLS) (1954). Diagnosis and improvement of saline and alkali soils. USDA Agri. Handbook. No 60.

Zubaidah I, Budhi P, Sharif MS (2011). Monitoring and management issues of heavy metal pollution of Gombak River, Kuala Lumpur. Int. J. Phys. Sci. 6(35):7961-7968.