http://www.e-journals.in
DOI:10.7598/cst2015.307

Chemical Science Transactions
2015, **4(3),** 682-688

RESEARCH ARTICLE

Impact Assessment of Runoff from Coal Mine on Ashokpa River Kogi State, Nigeria

J. E. EMUROTU*, G. M. IBRAHIM and O. A. ABDULSALAAM

Department of Chemistry, Kogi State University Anyigba, Nigeria
judrotu@yahoo.com

Received 18 August 2014 / Accepted 17 September 2014

Abstract: The impact of runoff from coal mine on water quality of Ashopa river was investigated. Sampling points of river water include two upstream locations up to 200 m from discharge point, the discharge point, two points downstream and the runoff. The quality of the river was compared with that of some rivers from other parts of the world and with established standard (APCELS). The river water contained high average value of suspended solids (342 mg/L) and hardness (435 mg/L), but low concentrations of phosphate (3.3 mg/L), sulphate (4.4 mg/L), nitrate (0.44 mg/L), chloride (2.65 mg/L) and COD (20.8 mg/L). The pH and temperature were fairly constant. In addition, the overall concentrations of heavy metals were at baseline levels except Fe (5.5 mg/L). The impact of the runoff was low as there was no significant difference in water quality between upstream and downstream.

Keywords: Runoff, Assessment, Physicochemical properties, Surface water

Introduction

Much of the current concern with regards to environmental quality is focused on water because of its importance in maintaining the human health and health of the ecosystem. Fresh water is finite resource, essential for agriculture, industry and even human existence, without fresh water of adequate quantity and quality, sustainable development will not be possible[1]. Over the years however, water, especially in the form of rivers, stream and ocean has traditionally served as a means of waste disposal of materials such as feaces and other domestic waste products all over the world. As human population increases with a parallel expansion in industrial and agricultural activities, water sources became receiver of wastewater along with contaminants both from home and industries[2].

River water quality is often a useful indicator of the state of community health in underdeveloped countries, where, because of an inadequate supply of treated tap water, river water serves as a direct source of drinking water, in addition to its normal uses for irrigation, recreation and fishing. The impairment of river water in urban settlements of such communities has been shown to be the primary source of health hazards in some cases[3]. There is a strong relationship between human activities and pollution of the environment.

The recognition of this connection and need to protect human health, recreation and fish's production led to early development of water quality regulations and monitoring methods[4-5]. The water quality of Nigeria surface water bodies are believed to be deteriorating gradually particularly in the industrialized and densely populated area[6].

Regardless of the terminology or cause, water pollution can be categorized as either point or non- point. Point sources are based on the activities that produce the pollutants such as from a specific, identifiable source, usually a facility and is released at a known discharge point or outfall, usually a pipe or ditch, a ship, municipal sewer system, industry and power plants. Non-point source pollution on the other hand arises from the way the pollutants are discharged into the environments which are non-specific[7]. Unlike the practice in many developed countries, there are no municipal actions to regulate, monitor or mange the quality of rivers and the exact status of water quality often remains a matter of conjecture. The purpose of this study was to examine the water quality of and pollution trend of Ashokpa River, Nigeria. This is expected to provide a base line date on possible impact of an old coal mine runoff on the water body.

Experimental

The Ashokpa River is located in Okaba region of Ankpa Kogi State, Nigeria. Average annual temperatures ranges between 28- 32 ^{0}C. The sample region lies on $7^0 37'$ N, $7^0 24'$E. The area falls, within the tropical savannah climate with average temperature of 30 ^{0}C. Samples for the study were obtained during the month of May and June, 2010 from six different sampling sites. The water samples were collected following the standard procedure describe by America Public Health Association (1998). Temperature, pH and Dissolved solids were determined at location, using field equipment, while dissolved oxygen was fixed at sampling points by Winkler's method. All laboratory analyses were carried out using standard methods[8,9], while appropriate quality assurance procedures for water analysis[10] were observed. The specific standard methods used were as follows. The temperature was measured using calibrated mercury in glass thermometer (0 – 100 ^{0}C). Hanna H196107 pH meter calibrated with buffer solutions 4 and 7 was used for pH determination, alkalinity (acid-base titrimetry), hardness (EDTA titrimetry), chloride (mercurimetric titration), nitrate (phenoldisulphonic acid colorimetric method), dissolved oxygen (Winkler's titration), COD (potassium dichromate oxidation and titrimetry), sulphate (turbidimetry) and phosphate (molybdenum blue colorimetric method). Metals (Cd, Cu, Fe, Ni, Pb and Zn) area determined by atomic absorption spectrophotometry.

Chemicals

High purity chemicals and reagents used were analar grade. Double distilled desionised water was used in preparing solutions.

Results and Discussion

Temperature and pH values

The temperature ranges from 28 ^{0}C to 31 ^{0}C. Water temperatures were within the values of the ambient air temperature. The pH values ranged from a minimum of 5.6 to a maximum of 5.9. The values conform to World Health Standard. The pH of the runoff was low (2.0) and do not conform to WHO standard limits[11]. The runoff pH slightly affected the water pH as the pH at the point of discharge was 5.6 and slightly increases downstream.

Solids

The total dissolved solids (TDS) content of the river were within WHO standard limit of 500 mg/L. Average value of 314±32 mg/L was recorded for all locations. Values ranged from 270 mg/L to 360 mg/L. The highest value obtained for the runoff was 900 mgL. However down the stream the values declined gradually. The average TDS value compares fairly well with averages values obtained by UNEP for Asian, North America and European rivers (Table 3) but are higher than the 2001 average value of 308 mg/kg recorded for all rivers in Ibadan and 108 mg/L obtained by UNEP for some African rivers Table 3. Total suspended solids (TSS) levels for Ashokpa River were high; values ranged from 250 mg/L to 440 mg/L, with a mean of 342±82 mg/L (Table 1). The concentration of TSS at the point at which the runoff discharge into the river was 440 mg/L and the runoff value was 640 mg/L. UNEP mean TSS values for Asian rivers (154 mg/L) and European rivers (113 mg/L), as well as the average of 119 mg/L obtained for Ibadan rivers[12], are all lower than those of Ashokpa river (Table 1). High suspended solids levels may be attributed to direct discharges of domestic and waste from the coal mine. Water high in suspended solids may be aesthetically unsatisfactory for bathing[8]. Total solids are dependent on TSS and TDS. The high level of 800 mg/L observed at the point SW-3 may be attributes to the effluent runoff. Values decrease to 600 mg/L at point SW-5. The mean value for total solid was 652±105 mgL. The runoff from the coal mine records a value of 1540 mg/L.

Alkalinity and Hardness

Alkalinity ranged from 27.5 mg/L to 65.0 mg/L with a mean value of 43.5 mg/L (Table 1). These values were lower than reported values for Ibadan rivers[12]. The alkalinity of water is caused mainly due to OH, CO_3, HCO_3 ions. Total hardness values ranged from 292 mg/L to 541 mg/L. The average value of 435± mg/L for all locations is far higher than WHO standard limit[11].

Dissolved oxygen and chemical oxygen demand

Dissolved oxygen levels of the water sample for all location had a mean of 6.27 mg/L. Value obtained range from 5.74 mg/L to 6.7 mg/L (Table 1). Result obtained in this study compares fairly well with values obtained for many river systems around the world, where values are typically as high as 6.0-9.5 mg/L[13]. The mean value of dissolved oxygen obtained in this study means that the water body can support aquatic life as a minimum of at least 5 mg/L is essential to support aquatic life. Average value of 6.27 mg/L obtained from Ashokpa River is higher than what is obtained for Ibadan rivers[12,13] where values are typically as low as 2.5 mg/L and 5.2 mg/L. The COD values obtained ranged from 19.5 mg/L to 23.4 mg/L with a mean value of 22.4 mg/L. The runoff value from the coal mine was 28.6 mg/L. These values showed low level of non-easily degradable organic matter in the water body as levels were below the APCELS standard limit[14].

Anions (chloride, sulphate, nitrate and phosphate)

High anion contents may result from waste discharged into water coursed. Average concentration of 2.65 mg/L was observed for chloride in Ashopa River. This value fell below the 200 mg/L recommended[11,15]. Chloride values compared fairly with those obtained by UNEP/GEMS for African rivers but lower than for Asia, European and North America rivers[16] Also averages for sulphate (4.42 mg/L) and Nitrate (0.44 mg/L) were lower than many worldwide values. However, mean values for phosphate was higher than for most Rivers[17].

Table 1. Some general physicochemical characteristics of Ashopa River samples

Sample Code	pH	Temp., ^{o}C	TS mg/L	TDS mg/L	TSS mg/L	Alkalinity mg/L	Hardness mg/L	Cl^- mg/L	$N0_3^{-I}$ mg/L	$S0_4^{2-}$ mg/L	PO_4^{3-} mg/L	DO mg/L	COD mg/L
SW -1	5.9	28	540	310	250	27.5	468	2.95	0.10	5.09	1.57	6.70	19.5
SW-2	5.9	29	600	320	280	45.0	338	2.21	0.30	5.70	0.57	6.40	20.2
SW-3	5.6	31	800	360	440	65.0	537	1.47	0.90	3.10	3.00	5.81	23.4
SW-4	5.7	30	720	310	410	40.0	292	2.95	0.50	4.40	5.00	5.74	20.7
SW-5	5.7	31	600	270	330	40.0	541	3.68	0.40	3.80	6.50	6.59	20.2
Mean	5.76±0.13	29.8±1.3	652±105	314±32	342±82	44±14	435±115	2.65±0.84	0.44±0.30	4.4±1.0	3.3±2.4	6.25±0.45	20.8±1.5
SW-R	2.0	26	1540	900	640	5.00	2.00	0.02	1.12	0.32	7.00	0.07	28.6

SW: surface water; SW-R: Runoff

Table 2. Concentration of metals (in mg/L) in surface water

Sample code	Cd	Cu	Fe	Ni	Pb	Zn
SW -1	0.01	0.01	3.15	0.21	0.06	0.08
SW-2	0.01	0.01	3.75	0.05	0.07	0.12
SW-3	0.23	0.25	7.73	0.33	0.05	0.29
SW-4	0.02	0.02	6.51	0.09	0.09	0.20
SW-5	0.02	0.02	5.52	0.07	0.03	0.17
Mean	0.06±0.10	0.06±0.11	5.5±2.0	0.17±0.08	0.06±0.02	0.17±0.08
SW-R	0.30	0.50	8.15	0.03	8.15	0.28

SW-R: Runoff

Table 3. Values of physicochemical parameters of some other Rivers compared with Ashopa River

River	pH	Temp. ^0C	TS mgL^{-1}	TDS mg^{-1}	TSS mg^{-1}	Alkalinity mg^{-1}	Hardness mg^{-1}	Cl mg^{-1}	$N0_3$ mg^{-1}	$S0_4^{2-}$ mg/L	PO_4^{3-} mg/L	DO mg/L	COD mg/L	[Lit]
Ashopa rivers (mean)	5.76	29.8	652	314	342	44	435	2.65	0.44	4.4	3.3	6.25	20.8	This study
Ibadan Rivers (mean)	7.4	28	425	308	119	174	77.4	55.2	22.2	13.9	0.04	2.5	118	[12]
Ona, Ibadan (1975)	7.4	-	-	193	-	82.5	81	21.1	-	-	0.48	5.2	-	[13]
Asian Rivers (mean)	-	-	-	232	154	-	-	19.7	-	24.9	-	-	-	[16]
North American Rivers (mean)	-	-	-	249	172	-	-	17.5	-	48.1	-	-	-	[16]
European Rivers (mean)	-	-	-	439	113	-	-	103	-	67.5	-	-	-	[16]
African Rivers	-	-	-	108	303	-	-	4.29	-	4.4	-	-	-	[16]
Ishikiri, Japan	-	-	-	-	-	-	-	-	0.53	-	2.73	10.5	-	[17]
Waikato, New Zealand	-	-	-	-	-	-	-	-	0.2	-	1.58	9.0		[17]
Thames, UK	-	-	-	-	-	-	-	-	6.99	-	2.93	9.9		[17]
Eastern UK - (mean)	-	-	-	-	18	-	-	49	4.6	85	0.41	-	-	[23]

Heavy metals

The water samples metals were screened for heavy metals concentration. The samples were analyzed for Cd, Cu, Ni, Fe, Pb and Zn. The concentrations of heavy metals were generally low (Table 2) and comparable with those of many the rivers worldwide (Table 3) but the concentration of Fe was worthy of note as values ranged from 3.15 mg/L to 7.73 mg/L. The highest value was observed at the point of mixture of runoff and water body. The concentration of the runoff was 8.15 mg/L. Except for iron all the metals were consistent with those expected for a normal fresh water body as level permissible were within permissible limits and therefore can support aquatic life.

Quality classification for utility

A variety of water quality indices have been used in different parts of the world[18-22]. These generally utilise water monitoring data which include variable combinations of parameters such as pH, turbidity, suspended solids, phosphates, dissolved oxygen, and BOD and COD. The well known index of Prati[19] was applied to the data of this study using the parameters pH, suspended solid, dissolved oxygen and COD. The classification scheme is based on a scale of I-V, which corresponds, to variations from very good quality water suitable for drinking, irrigation and industrial use to even without treatment, to very bad quality water which is not fit for any of these purposes. Based on the Prati scale, Ashopa River fell in the class 111, which is indicative of slightly polluted water and can be treated in small amounts for use by private consumers. Although the runoff fell into the class V, the effect was not much as there was no significant difference ($p>0.05$) between in the physicochemical properties before and after the discharged of the runoff into the river. This may be as a result of volume of water in rainy season and therefore increased rate of dispersion downstream

Conclusion

The study has shown that water from Ashopa River was typical of slightly polluted freshwaters. The runoff has little impact on the freshwaters as the physicochemical analysis obtained from upstream and downstream did not differ significantly ($p>0.05$). Except Fe all other metals determined where within permissible limit and do not pose threat to human life.

References

1. Kumar N, “A View on freshwater environment” Ecology Environment and Conservation, 1997, **3**, 3-4.
2. Adeniyi A A and Okediyi, O O. Assessing the speciation pattern of lead and zinc in surface water collected from Abegede Creek Ijora, Lagos, 2004.
3. Adesinal H O, Urban Environment and Epidemic disease. Proceedings of National Conference on Development and the Environment (Ibadan, Nigeria: Nigeria Institute of Social and Economic Research (NISER), 1986, 234-256.
4. Yusuf K A and Osibanjo O, *Pak J Sci Ind Res*., 2006, **49(2)**, 88-96
5. Charis K B and Abbasi S A, *Int J Environ Studies*, 2005, **62(2)**, 137-145; DOI:10.1080/0020723042000243001
6. Adeniyi A A, Yusuf K A and Okediyi O O, *Environ Monit Assess.*, 2008, 1**37(1-3),** 451-458; DOI:10.1007/s10661-007-9780-5
7. Masters G M and Ela W P, “Introduction to Environmental Engineering and Science”, Pearson International, 3rd Edition, New Jersey, 2008

8. APHA-AWWA-WPCF. Standard Methods of Waste and Wastewater (Washington APHA-AWWA-WPCF), 1998.
9. Department of The Environment, Analysis of Raw, Potable and Waste Waters (London DoE), 1772.
10. USEPA. Environmental Indicator of Water Quality in the United States. EPA 841-R-96-002 (Washington: USEPA), 1996.
11. World Health Organisation (WHO). Our Planet Our Health Report on the WHO Commission on Health and Environmental Security, Sab Jose (Costa Rica), 1992, 20-22.
12. Onianwa P C, Ipeaiyeda A and Emurotu J E, *Int J Environ Edu Information*, 2001, **20(2)**, 107-120.
13. Ajayi S O and Adeleye S A. *Bulletin Chem Soc Nigeria*, 1977, **2(1-2)**, 71-85
14. APCELS. Asia Pacific Centre for Environmental Law. Water quality, surface water standard (TCVN 5942), 1993.
15. ASTM, Annual Book of ASTM Standard. Water and Environmental Technology. Philadelphia U.S.A, 1989, 515-580.
16. UNEP/GEMS, Global Environmental Monitoring System – Freshwater Quality Programme: Data Summary, 1994-1996.
17. Van der Leeden F, Troise F L and Todd D K, The Water Encyclopaedia, (Chelsea, MG Lewis Publisher), 1990.
18. Kemp P, *Water Res.*, 1971, **5(10)**, 943-956; DOI:10.1016/0043-1354(71)90029-7
19. Prati L, Pavnello R and Pesarin F, *Water Res.*, 1971, **5(9)**, 741-751; DOI:10.1016/0043-1354(71)90097-2
20. Moore C A, Classification System and Indices for Reporting and Determining the Effects of Management on Water Quality in South African Water Bodies (Report to the Department of Water Affairs and Forestry, Pretoria, South Africa), 1990.
21. Pesce S F and Wunderlin D A. *Water Res.*, 2000, **34(11)**, 2915-2926; DOI:10.1016/S0043-1354(00)00036-1
22 Simeonov V, Stefanov S and Tsakovski S, *Mikrochimica Acta*, 2000, **134(1-2)**, 15-21; DOI:10.1007/s006040070047
23 Neal C, House W A, Leeks G J L, Whitton B A and Williams A J, *Sci Total Environ.*, 2000, **251/252**, 557-573; DOI:10.1016/S0048-9697(00)00395-8