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Impact of Detergent Industry Wastes on Receiving Stream and Groundwater

[1]Babatope A. Alabadan, [2]James U. Egwoba and [3]Kehinde A. Adekola

[1]Department of Agricultural and Bioresources Engineering, Federal University Oye - Ekiti, Nigeria.
[2]Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria
[3]Department of Agricultural Engineering, College of Biological and Agricultural Engineering, Jilin University, Changchun China.
[1]babatope.alabadan@fuoye.edu.ng, [3]profkola@sina.com

Abstract

Water is a valued natural resource for the existence of all living organisms. Pollution of water bodies by industrial effluents is a growing concern and a serious problem in countries of the world because it causes hazard to human health, harm to aquatic flora and fauna, damage to structure and interference with legitimate uses of environment. The impact of the disposal of detergent industry wastes on receiving Asa stream and groundwater in Ilorin, Nigeria was investigated in March and September, 2008. Reconnaissance survey of the study area was carried out to locate the points of discharge of effluents, the length of stream and the position and depth of wells. Four hand-dug wells and a stream were used. Samples were taken from the five points and in replicates. Eighteen physicochemical properties of the samples were analyzed using standard methods. The obtained values were compared with standard permissible limits. The total dissolved solids for samples 1 to 5 were 248.5, 238.5, 180, 155 and 195 mg/L in March 2008 and 235, 250, 181, 161 and 201 mg/L in September 2008. All were within the permissible limits. The presence of heavy metals like Copper, Lead and Nickel were not detected in all the samples but the levels of iron were above the recommended safe level for drinking water. Magnesium was found to be between 0.42 to 21.4 mg/L and 0.5 to 20 16.5 mg/L for March and September respectively. The values obtained were within acceptable standards while most of the parameters determined were higher. Results showed that soap and detergent effluents lowered the quality of the groundwater and receiving stream water. The groundwater and stream water are not safe for drinking but can be used for irrigation purposes. There is the urgent need for the industry to comply with directives on handling wastes.

Keywords: *Detergent, Wastes, Disposal, Water, Quality, Standards*

1.0 Introduction

Natural water quality varies considerably for geographical, hydrological and ecological reasons but the concept of pollution is usually restricted to extremes of adulteration attributable to human activities. Pollution or extreme contamination is the introduction of large quantity of toxic substances liable to cause hazard to human health, harm to living resources (aquatic flora and fauna), damage to structure and interference with the legitimate use of environment (William and Donald, 2001 Emodi, 2020).

The transport media of pollution are air, water and soil. Classes of water pollutants include disease-causing agents like bacteria, oxygen-demanding wastes, water-soluble inorganic pollutants such as toxic metals and nutrients like water-soluble nitrates and phosphates. Water pollution affects drinking water supplies or causes the death of large number of fish and other aquatic lives (Austin, 1999). Mohanakavitha, et. al., (2019) reported that the area of cultivation by Kalingarayan farmers is reduced from 6000 to 3000 hectares because of the contamination in the Kalingarayan canal by the different polluting industries like tanneries, textiles and dyeing units located in Erode and Tirupur areas.

Pollution is normally most evident in the case of surface water bodies but this can be easily cleaned up. Pollution of groundwater is unseen and may build up slowly but once polluted, it is very difficult to clean up. Groundwater represents the largest reservoir of fresh water that is readily available to man and provides the most satisfactory source of potable drinking water either in form of bore and hand dug well (Taiwo, 2003). The quality of groundwater is influenced by natural and anthropogenic activities (Chandan et. al., 2013). Ahmed, (2012) examined the water quality of groundwater sources in the areas adjacent to the solid waste disposal sites in Kano metropolis, Nigeria to assess the possibility of groundwater contamination as a result of percolation of the leachates generated in the sites.

An improper and functional wastewater disposal system easily contaminates groundwater from shallow well (M.Nazih, et. al., 2016). Many of these disposal systems are small scale for treatment of wastewater from industries that rely on soil as the principle medium for final purification. High degree of purification can be achieved by relatively small depth of soil, cases of groundwater contamination resulting in diseases are known (Frederick and Edward, 2000).

Pollution of water bodies by industrial effluents is a growing concern and a serious problem in a number of countries of the world (Kanu and Achi, 2011). Industrial wastes can contain a wide range of chemicals that are difficult to treat in order to reduce their hazard to organism or structures. Most industrial waste in developing countries are untreated and are disposed and dumped in an unsafe manner and illegally in lakes, rivers and soil (Yapijakis and Wang, 2004, Lawal, 2005, Chukwu, et. al., 2008, Mwenda, (2014) and Okereke, et. al., 2016).

Environmental policy in wastewater management employed the command and control approach and lately adopted the various economic instruments that include effluent charges, subsides marketable permits, deposition and return system and environmental funds to induce more flexibility, cost effectiveness and efficiency into pollution control measures (EPA, 2004). Stewart, et. al., (2017) reviewed discharges from stormwater, wastewater (human), industrial and trade waste, and other potentially hazardous activities (such as agricultural practices, landfill and contaminated sites) that were not addressed in Plan Change 6A on water quality.

Biodegradable detergents cause problems if they enter our storm water systems, streams, rivers and ultimately the ocean. Detergent wastewaters have environmental impacts and must be treated by sewage treatment works. Even after treatment, the environmental impacts of some alternative builders remain. Some of them (alkyl phenols) are oestrogen mimics that can have serious detrimental effects on populations of aquatic animals, such as decreasing their ability to reproduce (EPA, 2004).

Omotayo, (2013) reported that the wastewater effluents discharged from the nearby oil companies and human wastes adversely affected and impaired the qualities of the water samples. Wuyep et al., (2007) reported on the biosorption of Cr, Mn, Fe, Ni, Cu and Pb metals from a petroleum refinery effluent by calcium alginate immobilized mycelia of polyporussquamosus. Emodi, (2020) study showed that the effluents from Emene industrial area of Enugu have much of negative impacts on the water quality of the receiving Ekulu River.

Asa stream is of economic, agricultural and environmental significance in Ilorin—the capital city of Kwara State, Nigeria. The stream receives effluents from industries located along its course, apart from domestic wastes and other activities carried out along it that contribute to its pollution (Kolawole, et. al. 2011).

It was also reported that the major identified source of pollution of Asa stream was direct runoff of effluents from the industries (Adekunle and Eniola, 2008, Eletta, et.al., 2005). Lawal, (2005) reported that the effect of industrial wastes disposal into Asa stream was localized near the detergent industry and required further treatment and monitoring. Progressive increase in the level of pollution caused by the industry will continue to affect the sources of drinking water for people, irrigation for agriculture and aquatic plants and animals. The objective of this study is to further investigate the impact of the disposal of industrial wastes from soap and detergent industry on the quality of receiving Asa stream and groundwater.

2.0 Methodology

2.1 Reconnaissance Survey

The study was conducted in Ilorin, North Central Nigeria (8°28'N, 4°38'E to 8°31'N, 4°40'E). Asa stream course enters the southern end of the industrial estate from Asa Dam and runs northwards through residential and commercial areas of Ilorin (Kolawole, et. al. 2011). The study area is a soap and detergents industry located at Asa Dam road, Ilorin that discharges its wastewater into the Asa stream. Reconnaissance survey of the study area was carried out prior to the collection of samples from the located wells. The survey was done to locate the points of discharge of effluents from the industry, locate the position and depth of wells and stream from where samples of water would be collected and to decide on the appropriate methods to be adopted in sampling.

2.2 Collection of Samples

Four hand-dug wells of varying depths and a stream were used for the research. The distances between the point of discharge of the effluent from the factory and the located wells were also measured and recorded. The samples were collected in the Dry and Wet seasons prevalent in Nigeria. The months of March and September were chosen for the dry and wet seasons respectively. Samples were taken from the five points and in replicates. The time of collection and point of collection of each of the samples were noted.

Procedures prescribed in the standard methods recommended by APHA, (1999) for the examination of water and wastewaters were followed for all analysis. Sampling bottles were rinsed two or three times during sampling process to obtain a truly representative of the existing water conditions. Pre-cleaned 2-litre plastic bottle containers were used to collect and preserve samples for laboratory analysis.

Eighteen physicochemical properties of the groundwater and receiving stream samples were analyzed using standard methods. They are pH, Total dissolved solids (TDS), Suspended Solids (SS), Calcium, Magnesium, Chloride, Lead, Iron, Copper, Nickel, Manganese, Sodium, Sulphate, Potassium, Bicarbonate, Carbonate, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Measurement for pH was taken as soon as possible but not more than six hours from the time of collection. The obtained values were compared with World Health Organization (WHO), European Commission (EC) and Federal Environmental Protection Agency (FEPA) permissible limits.

3.0 Results and Discussion

3.1 Presentation and Analysis of Results

3.1.1 Sampling

The water samples 1, 2, 3, 4 and 5 were collected from five different sources of well 1, well 2, well 3, well 4 and stream respectively. Table 1 gives the description of points and position where the four wells and a stream were located relative to the industry and point of effluents discharge.

Table 1: Location and Description of the Four Wells and Stream

Sample No	Depth (m)	Distance from industry (m)	Remark
Well 1	0.75	87.00	The well is covered with a painted steel plate, surrounding clean and a toilet facility nearby.
Well 2	0.80	91.40	The well is covered with an unpainted steel plate, surrounding unkempt and no toilet facility nearby.
Well 3	0.40	25.85	The well is covered with a painted steel plate and surrounding unkempt.
Well 4	0.75	34.77	The well is covered with a painted steel plate and surrounding unkempt from grasses.
Stream 5	0.87	37.95	The stream covered a large mass of land where the industry discharges their waste into the river.

The results of the eighteen parameters investigated during the analysis of the water samples from the wells and stream are presented in Figures 1 to 5 and Table 2 for the months of March and September respectively.

Table 2: Physicochemical Properties of Water Sample 5 from Stream

Parameter	March	Sept.	Lawal (2005) report	WHO (2011) limits	EC (2006) Limits	FEPA (1991) Limits	Remark
pH	6.9	6.1	6.82	6.5 - 8.5	6.5 - 8.5	6 – 9	Polluted
TDS (mg/L)	195.0	201.0		1000	1500	200	Acceptable
SS (mg/L) 192.5	182.0	34.5	30	NA	40	Polluted	
Calcium (mg/L)	47.2	50.0		75	100		Acceptable
Magnesium (mg/L)	24.1	25.0		30	50		Acceptable
Chloride (mg/L)	60	71.0	7.89	250		200	Acceptable
Carbonate (mg/L)	ND	ND					
Bicarbonate (mg/L)	93.5	95.0		500			Acceptable
Sulphate (mg/L)	140	150	5.025	400	250	500	Acceptable
BOD (mg/L)	125.5	140.0	2.49	20		50	Polluted
COD (mg/L)	500	44.0	3.33			20	Polluted
Copper (mg/L)	ND	ND		0.05			Acceptable

Nickel (mg/L)	ND	ND	0.10		Acceptable
Manganese (mg/L)	0.73	0.10	0.10		Polluted
Sodium (mg/L)	3.5	0.70	125		Acceptable
Potassium (mg/L)	2.8	1.3	18		Acceptable
Lead (mg/L)	ND	ND	0.05		Acceptable
Iron (mg/L)	0.95	0.71	0.30	0.2	Polluted

3.2 Discussion of Results

3.2.1 Sampling

The farthest well from the industry is well 2 while Well 3 is the closest. Well 3 have the least depth but the stream is the deepest.

3.2.2 Physicochemical Properties of Samples

Tables 2, 3, 4, 5 and 6 show the comparison of the obtained mean values for the parameters of each sample. The obtained results in March and September were compared with Lawal, (2005) report on the same stream and WHO (2011) and EC (2006) permissible limits for drinking water in Table 2 to be able to ascertain the level of contaminants present.

Only sample 5 in March and samples 3 and 4 in September had pH within the limits and satisfies the requirement specified by WHO (2011) and EC (2006) permissible limits. Samples 1, 2, 3 and 4 in March and samples 1, 2 and 5 in September were observed to have pH values that are well below the WHO (2011) and EC (2006) permissible limits. The acidic nature of the samples is due to the use of H2SO4 by the soap and detergent industry to lower the pH of the effluent in the treatment of waste before being discharge into the neighboring river. The industry employs the use of H2SO4 to neutralize the basic wastes produced because of the use of Sodium Hydroxide in the production of detergents. The effect of lower pH than the limit specified is that the water can cause pipeline corrosion aside from having a bitter metallic taste.

The values of iron obtained in all the five samples ranges from 0.58 mg/L to 0.75 mg/L for the month of March and September. A comparison of the iron values obtained in both seasons with the WHO (2011) and EC (2006) permissible limits of 0.30 mg/L and 0.20 mg/L respectively showed that the samples contained high concentration of iron. The samples are highly contaminated. The high iron concentration recorded can be attributed to the industrial waste or natural occurrence of iron as a mineral from sediments and rocks.

Samples 1 (0.6 mg/L, 0.30 mg/L) and samples 2 (0.50 mg/L) and 0.40 mg/L) contained appreciable quantity of Manganese for the month of March and September respectively. Samples 1 and 2 were slightly polluted because their values were higher than the WHO (2011) and EC (2006) permissible limits. The sample from the stream was equally polluted in March only. Manganese were not detected in samples 3 and 4. Consumption of water containing Manganese more than the specified limit by WHO (2011) can cause aching limbs, back pains, nervousness, drowsiness, nasal congestion and nose breading.

Sample 3 contained the lowest value of 0.5 mg/L sodium in all the samples and all the seasons. The highest values of 3.5 mg/L and 4.0 mg/L were recorded in Sample 5 in March and sample 1 in September respectively. However, the WHO (2011) and EC (2006) permissible limits of 125 mg/l for sodium is well above the obtained values of sodium contents in all the samples.

The potassium content as determined during the period of study in both seasons for the samples were found to be 3.0 mg/L in sample 1, 12.5 mg/L in sample 2 and 1.0 mg/L in each of samples 3, 4 and 5. The WHO (2011) permissible limits of 18 mg/L for potassium are far greater than the obtained values. The calcium contents of the all samples were found to be between 18.4 mg/L in sample 3 to 65.7 mg/L in sample 1. The WHO (2011) permissible limits of 75 mg/L and EC (2006) permissible limits of 100 mg/L for calcium were higher than the obtained values.

The chemical oxygen demand (COD) values of 480 mg/L, 430 mg/L, 30 mg/L, 20 mg/L, 500 mg/L were obtained for the samples 1, 2, 3, 4 and 5 respectively in March. The values in March are generally higher than the values in September. The high value of the COD can be attributed to the presence of chemical oxygen demanding substances, a quality which depends on the quantity of impurities present in water. All the values are higher than FEPA (1991) allowable limit of 20 mg/L.

The Biological Oxygen Demand (BOD) obtained are 80 mg/L, 100 mg/L, 40 mg/L, 40 mg/L and 44 mg/L for samples 1, 2, 3, and 5 respectively in March. The Biological Oxygen Demand (BOD) obtained are 78 mg/L, 98 mg/L, 40 mg/L, 48 mg/L and 140 mg/L for samples 1, 2, 3, 4 and 5 respectively in September. All the values are higher than the WHO, (2011), EC, (2006) and FEPA (1991) permissible limits. The BOD values in March are higher than the values in September. The higher value of Biological Oxygen Demand may be attributed to high presence of organic matters whose oxidation requires high amount of oxygen.

The WHO (2011) permissible limits of 1000 mg/L and EC (2006) permissible limits of 1500 mg/L for TDS were higher than the values obtained in all the samples. The values ranged from 155 mg/L (sample 4 and March) to 250 mg/L (Sample 2 and September).

The analysis carried out did not detect the presence of Carbonate, Copper, Lead and Nickel in all the samples. It can therefore be inferred that the effect of Carbonate, Copper, Lead and Nickel on groundwater and the stream in more pronounced in sample 1 and sample 5 than in sample 3 and sample 4. There is slightly high rate of contamination in the month of September in comparison than that of March.

The concentrations of Calcium, Magnesium, Chloride, Bicarbonate and Sulphate in all the samples were lower than the WHO (2011) and EC (2006) permissible limits. Calcium and Magnesium are responsible for hardness of water. Chlorides in drinking water are not harmful to human until high concentration of 1000 mg/L or more is reached. The industrial wastewater and human excreta discharged into the surface water is the possible source of chloride. Human excreta are known to contain about 6g of chlorides of person per day. The presence of sulphate in water can cause odour problem and there are no reported cases of such even by Lawal, (2005) in the same stream. The water is good for irrigation purposes.

The data were analysed using T-test and Pearson correlation at the 0.01 level (2-tailed) and 0.05 level (2-tailed) significance. Samples 1, 3 and 4 in March are significantly different at the 0.01 level (2-tailed) from Samples taken in September. Sample 2 in March are significantly different at the 0.05 level (2-tailed) from

Sample 2 in September. This may be due to the fact that Well 1, 3 and 4 are closer and shallower than Well 2. Sample 5 in March are not significantly different from Sample 5 taken in September. This observation may be attributed to the possible effort by the industry to treat their waste before discharging into the stream.

4.0 Conclusion

This study has proven that both the stream and groundwater were indeed polluted. The obtained values were higher than those reported in 2005 n the same industry and stream. This showed that there is progressive increase in the level of pollution caused by the industry and therefore the urgent need for the industry to comply with FEPA directives on handling wastes.

The groundwater and stream water were not safe for drinking, however, it can be used for irrigation purposes. It is therefore recommended that concerted efforts by the industries, dwellers and government to rescue the stream from the current hazard-posing environmental problems.

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