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IMPACT OF DOMESTIC WASTEWATER ON WELL WATER IN BARNAWA RESIDENTIAL AREA, KADUNA STATE, NIGERIA

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ABSTRACT

This study investigated the potential impact of domestic wastewater on well water in Barnawa residential area in Kaduna South Local Government Area of Kaduna State, Nigeria. Water samples were collected from a central sewage (CS), five wells around the sewage and a well (CW) which is 1 km away from the other wells to serve as the control. The physicochemical parameters: Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Turbidity, Total Suspended Solids (TSS) and pH of the water samples, were determined and concentrations of some heavy metals (Cd, Co, Ni and Pb) were determined using Atomic Absorption spectroscopy. The results showed that BOD values obtained ranged from 45.00±2.00 – 87.00±2.50 mg/L, T.D.S. 550±2.80 – 800±7.50 mg/l, Turbidity 15.5±1.00 – 22.7±0.50 NTU, pH 5.2±0.20 - 6.3±0.00 and T.S.S. 200±10 – 2729±141 mg/l. The mean concentrations of metals were Cd: 0.22±0.00 – 2.07±0.10 mg/l, Co: 0.18±0.00 - 0.25±0.01 mg/l, Ni: 0.31±0.00 – 4.16±0.20 mg/l and Pb: 0.11±0.00 - 0.22±0.00 mg/l. The BOD, TDS, Turbidity, TSS of CS and the heavy metals levels were above the control and WHO maximum permissible limits. Acidity of water makes it possible for easy dissolution of the heavy metals. This indicated potential health risk to humans as they depend on these hand dug wells for water when there is scarcity of portable water.

Keywords: Contamination, health risk, pollution, wastewater, well water

INTRODUCTION

One of the most important environmental issues today is ground water contamination [1]. Water of sufficient quality to serve as drinking water is termed potable water whether it is used as such or not. Although many sources are utilized by humans, some contain disease vectors or pathogens and cause long-term health problems if they do not meet certain water quality guidelines [2]. These resources are under threat of pollution from human life style manifested by the low level of hygiene practiced in the developing nations [3].

Wastewater can be defined as any water that is no longer wanted and is to be discarded after the initial or primary use. It is also regarded as water that contains waste from home activities such as bathing, washing and food preparation [4]. Uncontrolled discharge of toxic effluents to the soil, stream and rivers by industries and indiscriminate dumping of garbage and faeces have been reported to heavily contaminate groundwater in Nigeria [5]. Discharge of domestic and industrial effluent wastes, leakage from water tanks, marine dumping, radioactive waste and atmospheric deposition are major causes of water pollution. Heavy metals and industrial waste can accumulate in underground water, lakes and river, proving harmful to humans and animals [6]. Wastewater can be contaminated with different components which mostly include pathogens, synthetic chemicals, organic matter, nutrients, organic compounds and heavy metals.The household washing product contribution to the net residential heavy metals load in the residential waste water is 73% for arsenic, 6.5% for cadmium, 5.6% for chromium, and 3.2% for nickel [7]. For mercury, silver, lead, copper and zinc the contribution is 0.5% or less to the net residential waste water components [7]. These occur either in solutions or as particulate matter [8]. Oladoja[9] reported that residential wells and boreholes water are contaminated by sewage from the numerous septic tanks, latrines, and soak away pits often sited near them. It is also reported that 75 to 80% water pollution is caused by the domestic sewage. Domestic sewage contains toxicants, solid waste, plastic litters and bacterial contaminants and these toxic materials causes water pollution [10]. The majority of people drink water from these groundwater sources without any form of treatment. Indiscriminate dumping of materials laden with lead and other toxic metals on land and use of leaded gasoline had been shown to contribute to the lead load of underground water sources of many Nigerian cities [11, 12].

In addition, the improper disposal of solid and liquid waste near residential areas, poor waste collecting and handling, access roads and the state of physical infrastructure contribute to the sewage problems. In all these cases, it is expected that the direct input of organic species of biological origin, major and minor inorganic species and bacteria will occur in the aquifer. A considerable amount of domestic and industrial waste generated are dumped within the city. Some wastes are disposed through the sewer system or via the surface water courses [13]. Many of the small premises do not have access to any disposal system other than allowing waste to soak into the ground. Wastewater-contaminated soil and groundwater are located and noticed in many residential and industrial districts in many countries throughout the third world [14].The pollution of drinking water is responsible for a large number of mortalities and morbidities due to water-borne diseases like typhoid, cholera, dysentery, hepatitis as well as many protozoan and helminthic infestations [15]. Chronic exposure to toxins can lead to health problems like liver damage, gastro-enteritis, skin irritation, nervous system impairment and liver cancer in animals [16].

The aim of this study is to investigate the impacts of domestic wastewater in a central sewage on some selected wells in Barnawa residential area in Kaduna South Local Government Area of Kaduna State, Nigeria.

MATERIALS AND METHODS

Sample collection and Analysis

Water samples were collected from a central sewage (CS), five wells (W_1 – W_5) around the sewage (average distance of 40 m) and a well (CW) which is 1 km away from the other wells to serve as the control, all in Barnawa residential area in Kaduna South Local Government Area of Kaduna State, Nigeria. The water samples from each well were collected using a plastic drawer and were transferred to two separate 2 L plastic bottles.One of the bottles was acidified with 2 cm^3 conc. HNO_3 for metal analysis.The containers were tightly covered and stored in refrigerator at 4^oC in the laboratory for further analyses.

The physicochemical parameters (BOD, TDS, Turbidity, TSS and pH) of the water samples were determined as described in standard methods [17]. The water sample digestions were carried out in which 50 cm^3 of the sample was first treated with 20 cm^3concentrated HNO_3 and the mixture was heated to boiling on a hot plate. Heating continued until white fumes evolved. The digest was allowed to cool, filtered through ashlessWhatman filter paper no.42 into 100cm^3 standard volumetric flask and made up to the mark with distilled water. The concentrations of Cd, Co, Ni and Pb were determined using Atomic Absorption Spectrophotometer (AAS).The analysis was done in triplicate.

RESULTS AND DISCUSSION

Physicochemical Parameters

The results of the physiochemical parameters of the water samples analysed are shown in Table 1. The results showed that BOD values obtained range from 45.00±2.00 – 87.00±2.50 mg/L with central sewage having the highest value (87.00±2.50 mg/L) while W_1 has the least value (45.00±2.00 mg/L). All the studied sites have their values higher than the control (33.00±1.40 mg/L) and above the WHO standard of 7 mg/L. The biochemical oxygen demand (BOD) gives the relative oxygen requirement for the degradation of organic materials. For environmental conservation, BOD is set at less than 10 mg/L to prevent odour caused by the anaerobic decomposition of organic matter and water with BOD less than 4 mg/L is of good quality and levels greater than 10 mg/L are polluted as reported by Razak*et al*. [18]. Total dissolved solid (TDS) comprises inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonate, chlorides and sulphate) and small amounts of organic matter that are dissolved in water [19]. The maximum permissible standard by WHO for drinking water is 500 mg/l. The mean values obtained for this work are in the range of 550 mg/L to 800 mg/L. These indicate that all the values obtained are above the maximum permissible limit and can cause adverse effects when used for domestic and recreational purposes. The Total Suspended Solids were all below the WHO maximum permissible limit of 1500 mg/L, except for CS which has the highest value of 2729±141 mg/L. These values are in disagreement with that reported by Ibeto and Onianwa [20]. The filtering function of soil is an important ecosystem service for groundwater protection [21]. The turbidity values of the samples were all above the WHO maximum permissible limit of 5NTU for drinking water. The least turbidity value of 11.7 NTU was found in the control. All other samples have exceedingly high turbidity values with that of W5 leading by 22.7NTU.

Table 1: Physicochemical Parameters ofWater Samples from Barnawa Residential Area

	CS	CW	W1	W2	W3	W4	W5	WHO
B.O.D. (mg/L)	87.00±2.50	33.00±1.40	45.00±200	60.00±2.20	55.00±1.50	62.00±1.70	57.00±1.80	7
T.D.S (mg/L)	800±7.50	400±3.30	380±3.20	600±2.20	550±1.50	640±1.90	640±2.00	500
Turbidity (NTU)	22.70±0.50	11.70±1.00	16.70±1.20	19.20±0.45	15.50±1.00	20.70±0.40	18.40±0.55	5
pH	5.80±0.20	6.80±0.15	5.80±0.25	6.30±0.00	6.00±0.05	5.20±0.20	5.60±0.10	6.5 – 8.5
T.S.S (mg/L)	2729±141	287±27	310±11	330±10	380±21	350±22	200±10	1500

CS = Central sewage; CW = Control well; W = well

Material that causes water to be turbid includes clay, silt, finely divided inorganic and organic matter, algae, soluble coloured organic compounds, and plankton and other microscopic organisms. Turbidity has long been known to hinder disinfection by shielding microbes, some of them perhaps pathogens. Turbidity may indicate the presence of disease causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea, and associated headache. Higher turbidity increases water temperatures because suspended particles absorb more heat [8]. This is the most important significance of turbidity monitoring and therefore it has been an indication of the effectiveness of filtration and coagulation of water supplies [16]. This high turbidity values obtained in this research are in good agreement with Ibeto and Onianwa [19] in their preliminary study on the impact of poor waste management on ground water in some areas of Ibadan. The pH values for the water samples collected were below the WHO standard of 6.8 – 8.5 except that of control (6.8±0.15). Such low values of pH shows the water samples were acidic and are likely to be corrosive and therefore might not be suitable for drinking overtime. The increased acidity of raw water could be attributed to the presence of acidic metabolite or an indication of contamination of the water by household waste and sewage [22]. Acidity in water makes it possible for easy dissolution of metals especially heavy metals. The acidity of water samples from the five locations poses great danger if consumed by humans and can cause health problems such as acidosis which could have adverse effects on the digestive and lymphatic systems of humans [23]. Thus the pH of this water has to be adjusted in order to prevent it from being a health hazard.

Statistical analysis by ANOVA showed that there was no significant difference (P >0.05) in the values among the five wells which means the source of the pollutants is from the central sewage. But there was a significant difference ($P \leq 0.05$) between the values obtained from the central sewage and those of the five wells and the control well. This is an indication that the wastewater in the central sewage has impact on the surrounding wells. Natural water is said to be polluted when its physicochemical characteristics have been changed by humans such that it is no longer useful for its primary purpose. Health risk associated with polluted water includes different diseases such as respiratory disease, cancer, diarrheal disease, neurological disorder and cardiovascular disease [24, 25].

Concentrations of metals

Table 2: Concentrations (mg/l) of Metals in Water Samples from Barnawa Residential Area

	CS	CW	W_1	W_2	W_3	W_4	W_5	WHO
Cd	2.07±0.10	0.14±0.00	0.32±0.05	0.36±0.01	0.22±0.00	0.35±0.10	0.30±0.00	0.03
Co	0.25±0.01	0.10±0.00	0.21±0.00	0.19±0.01	0.18±0.00	0.20±0.01	0.22±0.00	NA
Ni	4.16±0.20	0.10±0.00	0.55±0.01	0.90±0.01	01.11±0.05	1.96±0.10	0.31±0.00	0.02
Pb	0.22±0.00	0.09±0.01	0.14±0.01	0.18±0.00	0.12±0.00	0.11±0.00	0.18±0.01	0.01

CS = Central sewage; CW = Control well; W = well; NA = Not applicable.

Table 2 shows the result for the concentrations of metals in the water samples collected from the central sewage, the various wells ($W_1 - W_5$) and the control well in Barnawa residential area. The results indicated that the mean concentrations of heavy metals analysed in the central sewage were higher than in the wells and the permissible limits recommended by WHO. The mean concentrations of Cd ranged from 0.22±0.00 – 2.07±0.10 mg/l with the central sewage having the highest value (2.07±0.10 mg/l) while the control well has the least value (0.14±0.00 mg/l). The maximum permissive limit set by WHO is 0.03 mg/l. This is of concern because Cd has carcinogenic properties as well as a long biological half-life [26] leading to chronic effects as a result of accumulation in the liver and renal cortex [27]. It can also cause kidney damage as well as produce acute health effects resulting from over exposure to high concentrations [26]. These figures for the concentration of Cd in the water samples are in agreement with that reported by Momodu and Anyakora [28] who studied heavy metal contamination of ground water in Surulere, Lagos and Abubakar *et al.* [29] who studied the heavy metal concentration in River Kaduna. The concentration of Co ranged from 0.18±0.00 - 0.25±0.01 mg/l. The value obtained for central sewage was highest (0.25±0.01 mg/l) and that of W_3 was the least (0.18±0.00). The concentrations of Co in all the wells and the CS were higher than that of the control, 0.10±0.00 mg/kg. Co concentration levels are very low in water samples as obtained in this study. It has been reported that Co is a natural earth element and is present in trace amounts in air, soil, water, plants and in our diets [30]. Human exposure to low levels of Co is by breathing air, eating food, or drinking water. Food and drinking water are the largest sources of exposure to cobalt for the general population [31]. However, high concentrations of cobalt may damage human health. Toxicological effects caused by the intake of excess cobalt include interstitial lung disease, vasodilatation, flushing, and cardiomyopathy in humans and animals [32]. All the water samples analysed were having Ni concentration above the WHO standard limit (ranging from 0.02 mg/kg). The well water is said to be contaminated. It has been reported that even in lower concentrations, Ni can cause allergic reactions apart from being carcinogenic [33]. Hair loss patients are related to contaminant drinking water and nickel can be related to derma toxicity in hypersensitive humans [34]. Nickel compounds are known carcinogens in both human and animal models [35, 36]. There is evidence that the genotoxic effects of nickel compounds may be indirect through the inhibition of DNA repair systems. As a result of this inhibition it has been suggested that accumulation of nickel in breast tissue may be closely related to malignant growth process [37]. The result indicates that Pb concentration in the study area in all the samples is higher than the WHO standard limit of 0.01 mg/kg. The highest concentration of Pb was found at CS (0.22±0.00 mg/kg) and the lowest concentration is W_4 (0.11±0.00 mg/kg) and the control value was found to be 0.09±0.01. These results are of concern as Pb has been recognized for centuries as a cumulative general metabolic poison [37]. Comparing with a study where a concentration of 0.1 mg/L had resulted in the development of neurological problem in fetuses and children [36], the results obtained in this study definitely require urgent attention. It has been reported that exposure to Pb is cumulative over time. High concentrations of Pb in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys. This damage commonly results in behaviour and learning problems (such as hyperactivity), memory and concentration problems, high blood pressure, hearing problems, headaches, slowed growth, reproductive problems in men and women, digestive problems, muscle and joint pain [34].

Statistical analysis using ANOVA has indicated that there was a significance difference ($P \leq 0.05$) between the metal levels in the studied wells and that of the control well which implies that the source of pollution in the wells was from the central sewage. People that consume high levels of heavy metals risk acute and chronic toxicity, liver, kidney, and intestinal damage, anemia, and cancer [38].

CONCLUSION

The result of this study indicated that the Central Sewage and wells have higher values of BOD, TDS, Turbidity, TSS and the heavy metals studied than those of control and WHO maximum permissible limits. This implies that the wastewater in the central sewage has impact on the surrounding wells. Acidity of water makes it possible for easy dissolution of the heavy metals. This indicates potential health risk to humans as they depend on these hand dug wells for water when there is scarcity of portable water.

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