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Evaluation of Contaminated Ground Water from Panteka Auto-Mechanic Spare Parts Market Kaduna, North West Nigeria

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Abstract

Contamination of groundwater with heavy metals from auto-mechanic sales and repair activities is a serious ecological problem, which has potential short and long term chronic adverse health risks. The objective of the study was to determine the concentrations of heavy metals in water samples from five wells within the Panteka auto-mechanic spare-parts market, Kaduna, Nigeria, compare the results with guidelines from various standard maximum limits, draw conclusions and make recommendations. Water samples were obtained from wells and analyzed for selected heavy metals using standard methods. A structured questionnaire was administered to traders and residents of the market so as to ascertain the usage of wells. The analysis of the heavy metals revealed high concentrations above that of the distilled water (DW) used as control, suggesting heavy metal contamination of ground water. The highest mean concentration of the heavy metals analyzed were 0.79±0.18, 0.13±0.09, 1.36±0.99, 2.45±1.09 and 0.82±0.23 for Fe, Cu, Hg, Cd, and Pb respectively. When all the highest mean concentrations were compared for all the metals in the five wells, they decreased in the following order Cd > Hg > Pb > Fe > Cu. The concentrations of Hg, Pb, Fe and Cd in the five wells exceeded the maximum limit recommended by Standard Organization of Nigeria (SON) and World Health Organization (WHO) for safety of groundwater while copper was within the permissible limits. These results suggest that exposure to the contaminated groundwater in the market may predispose exposed populations to adverse health effects with prolonged usage of the well-water.

Keywords: groundwater, auto-mechanic market, lead, mercury, cadmium, iron, heavy metal

Introduction

Water after air is regarded as one of the most **elementary** need of man required for life to continue. Ground water contamination is nearly always the result of human activity. Virtually any activity whereby chemicals or wastes may be released to the environment, either intentionally or accidentally, has the potential to pollute ground water (Gbadegesin and Olabode, 1999). The automobile spare parts market is a secondary market of the automotive industry, concerned with the sales of all vehicle parts, accessories, chemicals and equipment to consumers. The automobile spare parts market provides a wide variety of parts of varying qualities and prices for nearly all vehicle makes and models. It encompasses parts for replacement, appearance, and performance as well as electrical propulsion (Anoliefo *et al.*, 2001). The soils of automobile spare parts markets are exposed to various contaminants such as heavy metals and Polycyclic aromatic Hydrocarbons (PAHs) from various sources which includes metal scraps, used batteries, spent engine oil, brake oil and other lubricants that accumulate on the automobile parts, tools, work-benches, floors and equipment (Odegba and Sadiqi, 2002). These contaminants have been known to easily pollute ground water by simple absorption or percolation when spilled onto the ground (Baker and Baehr, 2002).

Spent engine oil (SEO) also known as used oil refers to any lubricating oil that has served its service properties in a vehicle, is withdrawn from the meant area of application and considered unfit for its initial purpose. Contaminants such as used oil accumulates on the automobile spare parts, when the used oil is spilled onto the ground and it may then travel with surface runoff and percolate into the subsoil, ultimately reaching the aquifer system thereby resulting in the contamination of the groundwater (Mbah and Ezeaku, 2010). The ever increasing numbers of automobile spare markets over a wide geographical area constitutes a severe environmental problem such as groundwater contamination. These have contributed remarkably to the problem of ground water contamination in most cities because waste oil from automobiles contain oxidation products, sediments, water and metallic particles resulting from machinery wears, organic and inorganic chemicals used in oil additives and metals (European Environment Agency 2007). Different documented investigations show that the composite contents of these heavy metals and PAHs are toxic and therefore can damage various vital body organs such as the kidney. Human exposure to contaminated ground water at high levels may result in damage to several tissues, possibly resulting to death at excessive levels especially with used oil components (Vasquez-Duhalt 1989; Ochiogu et al., 2009; Patrick-Iwuanyanwu et al., 2009) Therefore, assessing the status of water quality from selected wells at the market by quantifying the concentrations of heavy metals in samples from these wells and examining the consequent potential health risks associated with exposure to these heavy metals has become an important task in preventing risk to natural life and public health.

MATERIALS AND METHODS

Description of Study Area

The Panteka auto mechanic spare parts market lies geographically between latitudes 100° 33.39 North to 7° 23.49 North and longitudes 70° 24.23 East to 70° 25.17East. It is located in Kaduna North West Local Government Area of Kaduna State and is bounded to the South by Badiko to the North by Kawo, to the East by the 44 Nigeria Army reference hospital and to the West by Tudun wada Kudeti. Five sampling wells designated as "Wells 1-5" were selected within the auto mechanic spare parts market and their GPS locations were taken using a Garmin Etrex 10 GPS device, model number XN2DR30660.

Panteka automobile spare parts market is also a historical commercial nerve center of the Kaduna municipal area. Various activities including welding, panel beating, vehicle repairs, servicing and sales of all vehicle parts, accessories, chemicals and equipment are carried out within the market. The market also plays host to a number of food vendors who utilize the water from the groundwater wells located within the market for cooking, washing, bathing and in some cases drinking.

Sampling Stations/Wells

Before the commencement of work, qualitative information were taken and five (5) wells were selected primarily based on the activities which occur in the study area and accessibility.

Questionnaire Administration

A structured questionnaire was used to validate the demographic information, such as age and sex of workers and individuals found in the spare part market. The questionnaire also helped ascertain the general usage of the well water and the purpose (such as cooking, drinking, washing, bathing and ablution) for which it is used including the types of activities that take place around each well in the automobile spare part market.

Collection of Groundwater Samples

Water samples were obtained five times at two weeks interval from seven wells located within the Panteka auto mechanic spare parts market Kaduna and designated wells 1-5 respectively. All the water samples were transported to the laboratory for heavy metal and PAHs analysis. A control sample of distilled water was also analyzed for similar parameters. The methods used are all detailed in APHA, AWWA, WPCF (1998).

Analysis of Water Sample

The analysis (heavy metals) of the water samples from the seven wells and distilled water control were carried out at the Department of Microbiology, Ahmadu Bello University Zaria and Federal Ministry of Agriculture and Rural Development Kaduna.

Heavy metals

The test water samples and distilled water control were digested according to the methods stipulated by APHA, (1989) and analyzed for Fe, Cu, Pb, Hg, and Cd using a Buck Scientific Atomic Spectrophotometer, model number 210/211 VGP.

RESULTS

Questionnaire Analysis and Interpretation

Water Usage

Table 1 shows that most of the respondents use the water daily and the highest percentage of usage was observed in well 1 (95%) followed by well 3 (90%), while few respondents use the water on a weekly and monthly basis. It was observed from the questionnaires analyzed that

20% of the respondents use well 1 for cooking, 30% of the respondent use well 2 for cooking, 15% of the respondent use well 3 for cooking, 20% of the respondent use well 4 for cooking, 10% of the respondent use well 5 for cooking. 25% of the respondents drink from well 1, 20% drinks from well 2 and 15% drink from well 3 18.8% drinks from well 4 and 20% drink from well 5. It was also observed from the questionnaires analyzed that 15% of the respondents use well 1 for washing, 15% of the respondent use well 2 for washing, 20% of the respondent use well 3 for washing, 20% of the respondent use well 4 for washing, 20% of the respondent use well 5 for washing. 20% of the respondent bath with well 1, 15% bath with well 2 and 20% bath with well 3. 13% bath with well 4 and 30% with well 5. It was also observed from the questionnaires analyzed that 20% of the respondents use well 1 for ablution, 20% of the respondent use well 2 for ablution, 30% of the respondent use well 3 for ablution, 28.2% of the respondent use well 4 for ablution, 20% of the respondent use well 5 for ablution. The result of the questionnaire shows that well 1 and well 3 had the highest percentage of usage which is an additional reason why it was selected for further study.

Table 1: Percentage Rate of Water Usage of the Five Wells
Respondent working /living around the wells

		Well 1(%)	Well 2(%)	Well 3(%)	Well 4(%)	Well 5(%)
Water usage	Cooking	20	30	15	20	10
	Drinking	25	20	15	18.8	20
	Washing	15	15	20	20	20
	Bathing	20	15	20	13	30
	Ablution	20	20	30	28.2	20
Rate of water usage	Daily	95	84.2	90	58.8	85
	Weekly	3.0	10.5	5.0	29.4	10
	Monthly	2.0	5.3	5.0	11.8	5.0

Heavy Metals Concentration in Well Water Samples

All information on the mean concentrations of the five heavy metals examined in this study is presented in (Table 2). The highest mean concentration of Fe was found in Well 3 at 0.79±0.18mg/L and it was significantly different from concentrations found in Well 1, 2, 4 and 5; the highest mean concentration of Cu was found in Well 5 at 0.13 ± 0.09 mg/L, Hg has the highest level in Well 1 at 1.36 ± 0.99. Cd had the highest mean concentration in Well 1 at 2.45 ± 1.09mg/L), the highest mean concentration of Pb was found in Well 3 at 0.82 ± 0.23mg/L. When all the highest mean concentrations were compared for all the metals in the five wells, they decreased in the following order Cd > Hg > Pb > Fe > Cu. The results for each heavy metal in the wells were compared with the Nigerian Standard for Drinking Water as provided by Standards Organizations of Nigeria (SON) and acceptable international limits of heavy metals in drinking water as provided by WHO (Table 2). The result shows that the concentration of Fe exceeded WHO and SON limit in Wells 3, 4 and 5. Hg also exceeded SON and WHO standards in Wells 1, 2, 3, 4 and 5. Cd also exceeded the two standards used in this study in all the five wells. The concentration of Cu was all within the acceptable drinking water limits provided by SON and WHO in all the five wells.

Table 2: Heavy Metal Analysis of Well Water Samples and Distilled Water

	Fe (mg/l)	Cu (mg/l)	Hg (mg/l)	Cd (mg/l)	Pb (mg/l)
CONTROL	0.01 ± 0.01[a]	0.01±0.01[a]	0.01 ± 0.01[a]	0.01 ± 0.01[a]	0.01±0.01[a]
WELL 1	0.15±0.11[b]	0.12±0.11[b]	**1.36±0.99[c]**	**2.45±1.09[c]**	0.37±0.06[b]
WELL 2	0.18±0.14b	0.11±0.07[b]	0.83±0.77[ab]	0.66±0.12[a]	0.66±0.32[b]
WELL 3	**0.79±0.18[c]**	0.12±0.07[b]	1.20±1.01[bc]	0.65±0.18[b]	**0.82±0.23[c]**
WELL 4	0.39±0.11[b]	0.12±0.08[b]	1.19±0.98[b]	0.65±0.13[b]	0.53±0.45[b]
WELL 5	0.73±0.17[c]	**0.13±0.09[c]**	1.18±0.86[b]	0.64±0.18[b]	0.51±0.21[b]
SON (2015)	0.3	1.0	0.006	0.003	0.01
WHO (2017)	0.3	2.0	0.001	0.003	0.01

DISCUSSION

It was observed that various anthropogenic activities such as repair and replacement of various auto spare parts, stacking of tyres, engine repairs, panel beating, hammering, dismantling of old vehicles into parts occurred around most of the wells analyzed in the market. These activities at the automobile spare part market generated toxic waste and chemicals such as heavy metals, Polycyclic aromatic hydrocarbon (PAHs), tyre leachates, effluents and used oil such as spent oil, engine oil, brake oil and other lubricants (Odegba and Sadiqi, 2002). These contaminants have been known to easily pollute ground water by simple absorption or percolation when spilled onto the ground. The public can be exposed in a variety of ways. The most serious risk of exposure is through the consumption of the contaminated ground water, but exposure may also occur through the direct contact to the skin or by breathing in water vapor (Okonokhua *et al.*, 2007).

It was also observed that the all heavy metals analyzed in the contaminated well water from the market exceeded that of the control, suggesting that the groundwater of the market was contaminated with heavy metals. The concentration of Fe, Hg, Cd and Pb in the five wells exceeded the maximum limit recommended by World Health Organization (WHO) and Standard Organization of Nigeria (SON) for safety of groundwater. Thus, their cumulative effect over time could be detrimental to human health and may cause some life threatening disease such as cancer (Halek and Nabi, 2006). The presence of various heavy metals in the water sample could be attributed to various anthropogenic activities carried out in the market which generate toxic waste and chemicals, which is a common practice in the area (Baker and Baehr, 2002). These results show obvious infiltrations of heavy metals into these well water samples, among which the Fe, Pb, Cd and Hg concentrations calls for attention as they exceeded the permissible limits in these wells. The high concentrations of heavy metals noticed in these wells were probably due to contamination with SEO and other automobile related activities in the spare parts market. Pb, Cd and Hg are particularly considered to be highly toxic, carcinogenic and dangerous to human health especially over a prolonged period of exposure (Anoliefo et al., 2010).

The results of the concentrations of heavy metals in the five well water samples is similar to a cross sectional study carried out by Khan *et al.*, 2013 on the health risks associated with heavy metals in the drinking water of Swat, Northern Pakistan where the concentrations of Cd, Cr, Ni and Pb are found to exceed the WHO and USEPA limits. The presence of the observed heavy metals in higher concentration in the contaminated water is therefore probably due to the indiscriminate dumping of SEO on the soil of the automobile spare part market which percolates onto the ground thereby polluting the ground water resulting in pollution and may lead to geoaccumulation, bioaccumulation and biomagnifications in the ecosystems. This is in agreement with (Adelekan and Abegunde 2011; Osu and Okereke, 2010; Ugoh and Moneke,

2011) that reported heavy metal contamination of soil and groundwater in auto mechanic workshops in the Nigeria environment (Odegba and Sadiqi, 2002).

CONCLUSION

The study assess the concentration of heavy metal in five well water samples at Panteka auto mechanic spare parts market in Kaduna, Northwest Nigeria. The results of this study reveal that the well water may not be safe for drinking as the concentration of some of the toxic compounds examined were found to exceed the acceptable national and international standards for drinking water. Therefore, there is an urgent need for proper control measures that protects the health of people working and living around the automobile mechanic spare part market. This is to ensure their safety. There is also need to create awareness among residents and workers in the study area about the dangers of continuous exposure to the water either via ingestion or dermal pathways. Also, efforts should be made to the removal of these toxic metals if people will continue to use or drink from the wells.

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