academicJournals

Vol. 7(9), pp. 891-898, September 2013
DOI: 10.5897/AJEST2013.1462
ISSN 1996-0786 © 2013 Academic Journals
http://www.academicjournals.org/AJEST

African Journal of Environmental Science and Technology

Full Length Research Paper

The impacts of auto-mechanic workshops on soil and groundwater in Ibadan metropolis

ADEWOYIN, O. A.[1]*, HASSAN, A. T.[2] and ALADESIDA, A. A.[3]

[1]Department of Zoology, University of Ilorin, Kwara State, Nigeria.
[2]Department of Zoology, University of Ibadan, Nigeria.
[3]Department of Biological Sciences, Federal University of Agriculture, Abeokuta, Nigeria.

Accepted 1 July, 2013

The extents of groundwater and soil pollution arising from auto-mechanic activities from auto-mechanic workshops at Ibadan metropolis were examined. Groundwater and top soil samples from auto-mechanic villages and control site were collected fortnightly over a period of two months and analysed for both physicochemical parameters and some heavy metals. Results of physicochemical parameters of groundwater ranged from 23 to 29°C for temperature, 0.25 to 8.64 mg/L for DO, 0 to 52.19 mg/L for BOD, 14.7 to 205.86 mg/L for COD, 5.63 to 7.33 for pH, 18 to 133 mg/L for total alkalinity, 23 to 287 mg/L for total hardness, 2 to 32.75 F.T.U for turbidity, 187 to 268 µs/cm for conductivity, 0.7 to 44.6 mg/L for TSS, 135 to 248 mg/L for TDS, 136.3 to 292.6 mg/L for TS, 0.03 to 62.1 mg/L for nitrate, 2.37 to 12.02 mg/L for phosphate, and 0 to 55.6 mg/L for oil and grease. Results of heavy metals analysis for groundwater ranged from 0 to 1.132 mg/L for Cd, 0 to 24.46 mg/L for Pb and 0 to 24.6 mg/L for Fe. Statistical analysis, using Pearson's correlation coefficient indicated correlations of some parameters at $P \leq 0.01$ and 0.05. The mean and standard deviations of the parameters were also calculated. The daily activities of auto-mechanic workshops have negative impacts on both soil and water.

Key words: Ibadan Metropolis, mechanic workshop, pollutants, soil, groundwater.

INTRODUCTION

The environment is the totality of biological and non-biological factors that affects an organism's life, making up the abiotic and biotic components. That is, the environment describes all plants and animals (living or dead), land, water and air (Bayero, 2004). There are various changes which occur in the environment, due to natural or artificial causes. Major factors contributing to environmental problems include human population increase, industrial development and urbanization, unsustainable use of resources and local changes (Botkin and Keller, 1997). Maduka (2004) defined pollution as the introduction, by man, into the environment, substances or energy, liable to cause hazard to human health, harm to living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment.

Environmental pollution is therefore the unfavourable alteration of our environment as a result of wastes from man's activities, changes in radiation levels, physico-chemical characteristics and abundance of organisms in a harmful way (Miller, 1988). Thus, a pollutant is a substance that occurs in the environment, at least in part, as a result of human activities, and which has deleterious effect on the environment (Bayero, 2004). Land pollution deals with the terrestrial environment; which extends from the top of the growing vegetation tothe capillary fringe

*Corresponding author. E-mail: tomi_adewoyin@yahoo.com.

of groundwater, the primary home of most living things on earth. The rains carry non-degradable pollutants and wastes into the soil, groundwater and nearby streams (Maduka, 2004).

According to USEPA (1993) and UN (1991), some of the undesirable elements that commonly pollute the environment include natural organics (phenols, for-maldehyde); heavy metals (lead, nickel, zinc, cad-mium, copper, chromium); inorganic (ammonia, cyanides, fluorides, nitrites, and sulphites); synthetic organics (pesticides, herbicides, detergents); acid and alkaline substances; mineral oils, fats and floatable substances; suspended solids and colloids; nutrient substances like nitrogen, phosphorus, sulphates as well as radioactive materials.

In mechanic workshops, there are accidental or deliberate releases or discharge of petrol, diesel, solvents, grease, and lubricants on the land and the atmosphere. Many of these petroleum products are organic chemicals that can be highly toxic and hazardous to soil fauna and man. The use of automobiles has also led to trace element and heavy metals-contaminated soil, which have grave consequences for soil dwelling organisms (Gupta and Gupta, 1998). According to Gupta and Gupta (1998), the toxicity or effects of heavy metals are consequences of an organism's position in the food chain, while in others; they are based on the genetic abnormalities as a result of physiological impairments.

Due to the STRONG implications of pollution by auto-mobile workshops on the environment and the cosmopolitan nature of Ibadan City (tagged the largest city in West Africa), this study was carried out to determine the pollution effects of auto-mechanic work-shops on the soil and groundwater environment of Ibadan metropolis and identify the implications of this on the immediate environment and planning of the metropolis to meet millennium development goals.

MATERIALS AND METHODS

Study area

Ibadan is the capital city of Oyo State, Nigeria; the largest city in West Africa and the second largest in Africa. It has a land size covering an area of 240 km^2 and with human population of 3,570,000 by 2006 census. The city is located between longitude 2° 50` and 3° 20` East of Greenwich Meridian and latitude 7° 20` and 70° 50` north of the Equator. Ibadan Metropolis is made up of five Local Government Areas; these are Ibadan North, Ibadan Northeast, Ibadan Southeast, Ibadan Southwest and Ibadan Northwest (Figure 1).

Sampling locations

Samples were collected from three mechanic villages, one each from three of the five local government areas within the Ibadan Metropolis. These included the Bodija Mechanic Village, Ibadan North Local Government, Oke-Ado Mechanic Village, Ibadan Southwest Local Government and Ijokodo Mechanic Village, Ibadan Northwest Local Government, while the Botanical Garden of the University of Ibadan served as the Control Site.

Soil collection and analysis

Soil samples from top soils at 0 to 10 cm depth, was collected at five points at each sampling location. Each composite sample was then bulked down to one representative sample. The soil samples from each site were kept in polyethylene soil bags labelled appropriately. Sampling was carried out twice with approximately two weeks interval between each sampling period. The soil samples were taken to the laboratory, spread out on sheets of paper, and air-dried in a dust free environment at room temperature (29°C) for a period of seven days. The soil samples were then pulverized with a porcelain mortar and pestle; and later sieved through a 2 mm mesh-sized sieve. The sieved soil samples were then analysed to determine oil and grease, lead, iron and cadmium using standard methods as specified by AOAC (1978).

Collection and analysis of water samples

Water samples for physicochemical analysis were collected with plastic containers, 4 L each, from wells found within the mechanic villages. Water samples were also collected from a borehole found at Bodija market. Samples for Dissolved Oxygen (DO), and biological oxygen demand (BOD) were collected and preserved using the method described by APHA (1998). Samples for oil and grease analysis were collected in wide mouth glass bottles that had been earlier washed with soap, rinsed with water, and finally rinsed with solvent to remove any oil and grease that might interfere with the analysis. Using standard laboratory procedures as described by the APHA (1998), the following parameters were analysed in the water samples, pH, turbidity, conductivity, total solids, total dissolved solids (TDS), total suspended solids (TSS), total hardness, total alkalinity, dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), NO3, Phosphate, oil and grease. Dissolved metals (lead, cadmium and iron) were determined by Atomic Absorption Spectrophotometer (APHA, 1998) at the Central Science Laboratory, Obafemi Awolowo University, Ile-Ife, Nigeria.

Data analysis

The data collected were statistically analysed to check the significance of the means of physicochemical parameters of the soil and groundwater samples.

RESULTS AND DISCUSSION

Physicochemical properties of the water samples

The chemical character of any water determines its quality utilization (Elueze et al., 2004). The quality is a function of the physical, chemical, and biological parameters to which it could have been subjected to and a particular use it is intended for (Tijani, 1994). The temperature range observed were slightly lower than the values observed by Oni (2000) who observed a temperature range (28 to 30°C and 27 to 30°C) of groundwater at Ibadan and this is also very close to the values observed by Olayinka et al. (1999) who observed a temperature range of 26.7 and 29.10°C on shallow

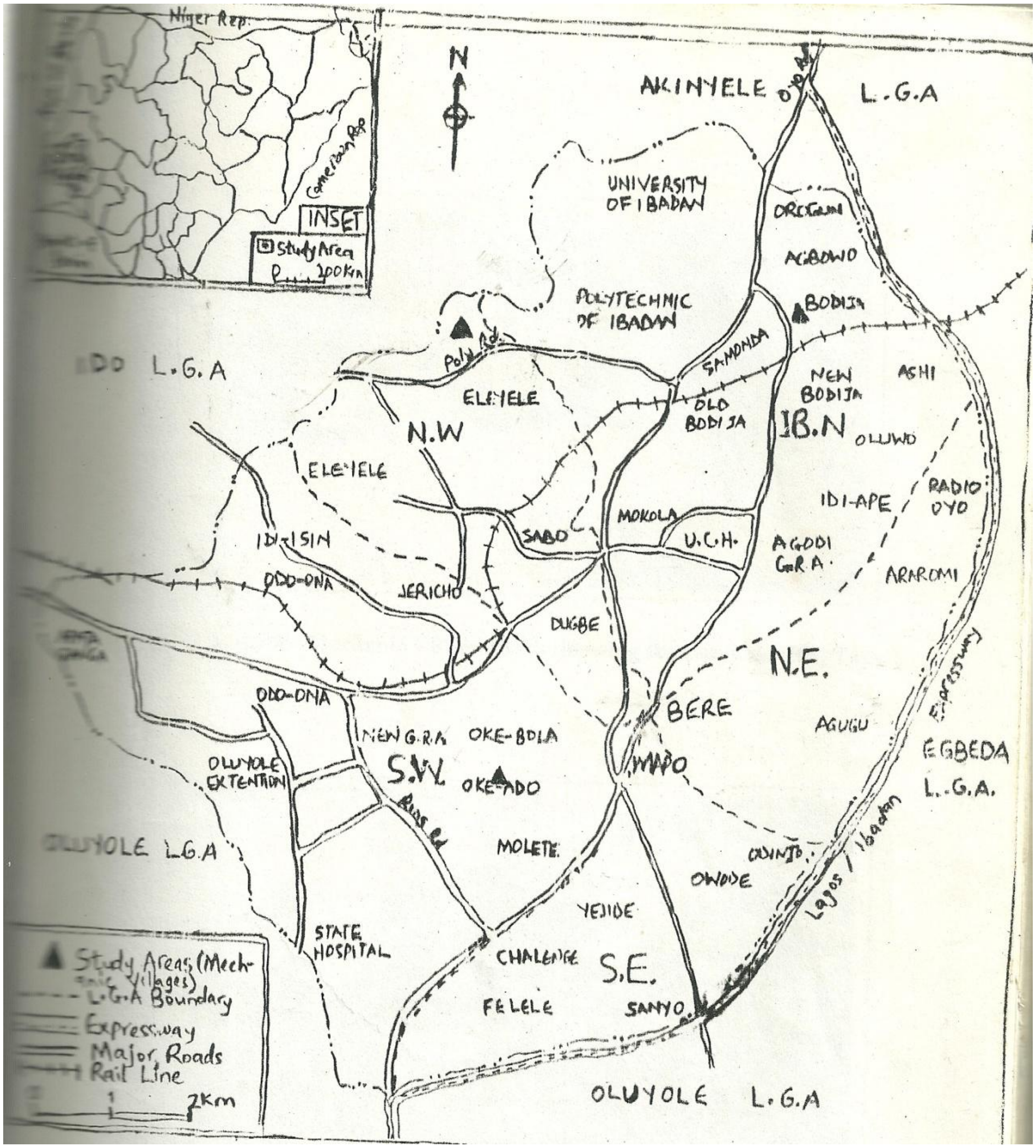

Figure 1. Map of the study area showing the sampling locations.

groundwater of Ibadan. There was significant correlation between temperature and conductivity (P≤0.01) (Table 2). The measure of the capacity of natural water to neutralize acid is alkalinity. Total alkalinity correlated significantly with total hardness, turbidity, conductivity, total suspended solids, total dissolved solids, total solids and pH (P≤0.01) (Table 2). This is related to the work of Oni (2000) who also observed significant correlation of total alkalinity with pH, conductivity, total dissolved solids and total hardness (P≤0.05). Hardness could be associated with the depth of the well, closeness of well to a stream, the geological location and some other factors.

Hardness values recorded for the control site, Bodija mechanic village well and Bodija mechanic village borehole (Table 1) were lower than FEPA limits (Appendix I). While the values recorded for Oke Ado mechanic village well and Ijokodo mechanic village well (Table 1) were slightly higher than FEPA limits. Water with hardness value less than 50 mg/L is soft, 50 to 150 mg/L is hard and higher than 300 mg/L is very hard (Tchobanoglous and Schroeder, 1985). With this classification, water samples from Bodija mechanic village well and Bodija mechanic village borehole are soft, while those from Oke Ado mechanic village well and

Table 1. Group statistics of the other physicochemical parameters of groundwater in the sampling locations.

Parameter	Control	Bodija well	Bodija borehole	Oke-Ado well	Ijokodo well
Temperature	26.83±0.76	28.67±0.29	27.50±0.50	27.50±0.50	27.83±0.58
Conductivity	263.67±1.53	192.33±5.51	207.33±7.51	255.33±14.19	240.33±11.06
Nitrate	0.38±0.31	7.35±1.58	1.21±0.12	23.55±19.00	44.47±29.25
Phosphorus	7.10±1.23	5.58±5.58	6.72±0.58	3.32±0.92	3.11±0.06
Oil & grease	0.27±0.31	7.47±10.81	0.67±0.31	18.73±31.93	0.20±0.20
Ph	6.43±0.16	5.87±0.27	6.11±0.38	7.17±0.19	6.84±0.36
DO (mg/L)	1.85±1.21[a]	0.8033±0.48[a]	3.56±4.40[a]	0.91±0.33[a]	0.70±0.45[a]
BOD (mg/L)	17.44±15.28[a]	31.93±12.25[a]	10.16±11.35[a]	19.01±8.99[a]	36.03±23.40[a]
COD (mg/L)	73.52±58.82[a]	104.42±24.28[a]	39.94±29.75[a]	83.32±69.49[a]	122.54±88.63[a]
Alkalinity	65.83±5.39[c]	21.00±3.00[a]	38.33±1.16[b]	130.33±9.26[d]	45.12±6.25[b]
Hardness (mg/L)	84.50±4.77[b]	36.17±13.51[a]	37.00±6.08[a]	285.33±2.89[d]	259.67±11.30[c]
Turbidity (f.t.u.)	2.99±0.86[a]	9.13±0.99[b]	4.08±1.10[a]	31.59±2.25[d]	22.91±2.67[c]
TSS (mg/L)	0.76±0.09[a]	1.44±0.14[a]	1.29±0.08[a]	41.57±3.33[c]	26.11±6.10[b]
TDS (mg/L)	136.62±0.51[a]	152.00±3.61[b]	141.00±6.56[a b]	244.00±3.61[d]	171.13±13.11[c]
TS (mg/L)	137.38±0.56[a]	153.44±3.74[a]	142.29±6.60[a]	285.57±6.81[c]	197.24±19.21[b]
Cadmium (mg/L)	0.29±0.27[a]	0.15±0.25[a]	0.33±0.58[a]	0.06±0.11[a]	0.49±0.58[a]
Lead (mg/L)	7.53±9.13	7.61±13.18	16.89±6.56	21.35±4.91	6.59±5.71
Iron (mg/L)	3.80±3.34	10.90±10.31	6.93±6.19	8.43±14.01	0.23±0.41

Means with the same superscript in a row are not significantly different.

Ijokodo mechanic village well are hard. Total hardness correlated significantly with total alkalinity, turbidity, total suspended solids, total dissolved solids, total solids, nitrate and pH ($P \leq 0.01$) and also with conductivity and pH ($P \leq 0.05$) (Table 2). This is also related to the work of Oni (2000) who observed significant correlations of total hardness with pH, conductivity, total suspended solids, total dissolved solids, total solids and total alkalinity ($P \leq 0.01$). pH measures the degree of acidity or alkalinity of water and it determines some reactions (APHA, 1998). This probably explains the significant correlation of pH with total alkalinity ($P \leq 0.01$) (Table 2).

Conductivity is the ability of a solution to pass electric current; it gives the total ionic strength readings of the solution. Conductivity increases with temperature. However, in this work, there was an inverse relationship between conductivity and temperature ($P \leq 0.01$) (Table 2). Since conductivity gives total ionic strength readings, this is why it correlated with total hardness ($P \leq 0.05$) since hardness measures calcium and magnesium concentrations. It also correlated significantly with total alkalinity ($P \leq 0.01$) and pH ($P \leq 0.05$) (Table 2). All the values of TDS (Table 1) are lower than the FEPA limit (Appendix I). Arising from the work of Caroll (1962), all water sources in the study area are classified as fresh based on the proportion of TDS which fall between 0 to 1000 mg/L. The TDS values observed are also within the range of the values (60 to 455 mg/L) observed by Oni (2000) and Elueze et al. (2004) who observed TDS range of 23.4 to 763.20 mg/L. Tijani (1994) had earlier stated that the water typical of the Nigerian basement can be characterized as chemically Ca-HCO_3 type having relatively low TDS values. TSS values (Table 1) fall within the FEPA standard (Appendix I). TSS correlated significantly with total alkalinity, total hardness, turbidity, total dissolved solids, total solids, nitrate, pH ($P \leq 0.01$) and inversely with phosphate ($P \leq 0.05$) (Table 2). This result corroborates that of Oni (2000) also observed positive correlations between TSS and total solids, total hardness and pH. The level of dissolved oxygen in natural waters is often a direct indication of quality, since aquatic plants produce oxygen, while microorganisms generally consume it as they feed on pollutants. It is essential for the support of fish and other aquatic and aids in the natural decomposition of organic matter. Dissolved oxygen is temperature dependent.

FEPA limit of DO for drinking water is 7.5 mg/L (Appendix I). All values of DO (0.25 to 2.64 mg/L; Table 1) were lower than this FEPA standard, an indication of pollution. Dissolved oxygen in natural waters depends on the physical, chemical and biochemical activities in the water body (APHA, 1998). The acceptable limit of dissolved oxygen for aquatic life is 6.8 mg/L (FEPA, 1991). The BOD values, (Table 1) observed was not in accordance with that of FEPA (Appendix I). The BOD values observed were higher than those observed by Oni (2000) who observed BOD values ranging from -13.0 to 27 mg/L. The COD values observed were very high, showing a high level of contamination of the water samples. Since it has been stated earlier that dissolved oxygen in natural waters depends on the physical, chemical and biochemical activities in the water body (APHA, 1998), the depletion of the oxygen load in the groundwater sampled can be linked to the high chemical

Table 2. Inter-correlational matrix of physicochemical parameters of the water sample during the study.

Parameter	Temp	DO	BOD	COD	T. Alk	T. hard	Turb	Cond	TSS	TDS	TS	O&G	pH	Cd	Pb	Fe
Temp	1															
DO	-0.275	1														
BOD	0.387	-0.055	1													
COD	0.162	-0.072	0.896**	1												
T. Alk	-0.385	-0.117	-0.188	-0.028	1											
T .Hard	-0.112	-0.293	0.184	0.233	0.688**	1										
Turb	0.106	-0.375	0.263	0.304	0.674**	0.923**	1									
Cond	-0.642**	-0.191	-0.011	0.174	0.705**	0.585*	0.380	1								
TSS	-0.064	-0.293	0.193	0.283	0.755**	0.944**	0.973**	0.502	1							
TDS	-0.035	-0.258	0.084	0.181	0.844**	0.821**	0.916**	0.430	0.944**	1						
TS	-0.019	-0.281	0.118	0.220	0.818**	0.855**	0.948**	0.436	0.968**	0.99**	1					
O&G	-0.121	-0.119	0.174	0.429	0.421	0.249	0.392	0.185	0.391	0.474	0.455	1				
pH	-0.349	0.026	-0.106	-0.092	0.743**	0.869**	0.701**	0.624*	0.767**	0.693**	0.704**	-0.070	1			
Cd	-0.240	-0.214	-0.334	-0.335	-0.177	0.022	-0.122	-0.042	-0.138	-0.267	-0.252	-0.018	0.005	1		
Pb	-0.094	0.028	-0.239	-0.080	0.456	0.157	0.294	0.146	0.347	0.406	0.426	0.312	0.112	-0.242	1	
Fe	-0.011	0.050	0.046	0.192	0.053	-0.164	-0.029	-0.210	-0.036	0.096	0.041	0.888**	-0.195	0.075	0.055	1

**P≤0.01 *P≤0.05, T. Alk: Total alkalinity, T. hard: total hardness, O&G: oil and grease, Turb: turbidity, Temp: temperature, DO: dissolved oxygen, BOD: biochemical oxygen demand, COD: chemical oxygen demand, Cond: conductivity, TSS: total suspended solids, TDS: total dissolved solids, TS: total solids.

activities likely to be going on in the water; due mainly to seepage of heavy metals from soil at mechanic workshop. One of such chemical activity as described by Okonkwo (2000) is chemical oxidation processes (COD), like oxidation of iron to ferrous and ferric ions. The oil and grease content in the water samples was very high, except that from the first sample of the control site (Table 1). This might probably be due to all sorts of domestic activities (such as washing of plates, etc) being carried out around the borehole which makes the oil to seep down and percolate into the water.

The cadmium level (Table 1) in water samples was well above the FEPA standard (Appendix I). Cadmium is released from automobile batteries or car pigments. There was, however no correlation between cadmium and any of the other parameters and other metals. The values of lead recorded during the sampling (Table 1) were extremely higher than FEPA limit (Appendix I).

The high values of lead in the water samples are due to the use of leaded gasoline in Nigeria, lead from car batteries or from paints combined with arsenic (lead arsenate in sprays). No correlation was observed between lead and any of the other parameters and other metals. The values of iron recorded during the sampling (Table 1) were extremely higher than FEPA limit (Appendix I).

The high values of iron might be from the metal scraps of the various car parts in which iron is a component. Iron correlated significantly with oil and grease (P≤0.01, Table 2).

Physicochemical properties of the soil samples

The mean values of oil and grease recorded during the sampling were (12.67±10.26), (13.33±3.69) and (8±7.70) at Bodija mechanic village, Oke Ado mechanic village and Ijokodo mechanic village, respectively (Table 3). These were all significantly higher than that observed at the control site (0.5±0.5) and the permissible level of FEPA (Appendix II). Oil and grease reduce air spaces in soil thereby limiting available oxygen to support life. The mean values were (0.74±0.65), (0.62±0.54), (0.29±0.28), and (0.61±0.72) at the control site, Bodija mechanic village, Oke Ado limit of application of cadmium to soils as recommended by DOE/NWC (1981) (Appendix

Table 3. Descriptive statistics of the soil parameters measured during the study.

Parameter	Control site	Bodija mechanic site	Oke-Ado mechanic site	Ijokodo mechanic site
Cadmium	0.74±0.65[c]	0.62±0.54[bc]	0.29±0.28[a]	0.61±0.72[bc]
pH	6.33±0.32[a]	6.77±0.06[a]	7.10±7.10[a]	6.93±0.29[a]
Lead (Pb)	210.81±206.04[c]	258.46±224.69[d]	160.89±141.09[a]	199.68±185.41[b]
Oil and grease	0.50±0.05[a]	12.67±10.26[c]	13.33±3.69[c]	8.00±7.70[b]
Iron (Fe)	172.58±58.75[ab]	232.47±24.33[c]	168.73±10.32[a]	196.02±47.44[b]

Means with the same superscript in a row are not significantly different.

III), the mean values of cadmium (Table 3) obtained from the sampling locations were still within the acceptable limit. The values were, however, higher than the limit for land application recommended by FEPA (1991) (Appendix II). The cadmium values observed are higher than those observed by Ladunni (2004), who observed cadmium values ranging from 0.012 to 0.021 mg/L from top soils of auto-mechanic workshops at Ibadan. Fayemi (1998) observed cadmium values ranging from 0.21 to 2.70 µg g^{-1} from soils of high traffic density areas of Ibadan city, < 0.02 to 1.77 µg g^{-1} from soils of medium traffic density areas, and 0.15 and 1.25 µg g^{-1} from soils of low traffic density areas of Ibadan city. Also, Jaiyeola (1999) observed cadmium values ranging from 0.8 to 4.1µg g^{-1} from top soils of mechanic workshops in Ibadan city.

The mean values of lead recorded during the sampling were (210.81±206.04), (258.46±224.69), (160.89±141.09) and (199.68±185.41) at the control site, Bodija mechanic village, Oke Ado mechanic village and Ijokodo mechanic village, respectively (Table 3). The lead values observed are quite higher than those observed by Ladunni (2004), who observed lead values ranging from 0.68 to 5.82 mg/L from top soils of auto-mechanic workshops at Ibadan. This brings worry, when it would have been expected that such records should evolve from government, stricter measures in the management of such workshop.

However, a situation where the present work, carried out almost ten years after Ladunni (2004), gives higher lead and other metal loads in the soil, informs that nothing is been done or the measures being employed are not effective. More worrisome is the hazardous nature of most of these elements in water and the soil. An increasing release of these substances into the soil and its leaching into groundwater, presents very serious problems to users of such water bodies and soil fauna.

Conclusion

There are many different chemicals, substances and processes used at an auto-mechanic workshop, which are potentially dangerous both to the environment and to the health of human beings as well as animals. It was clear from the results of the analytical studies of the physicochemical parameters and heavy metals determination of both soil and groundwater from auto-mechanic villages, of Ibadan metropolis that there is a high degree of contamination and pollution. It has been observed that the various pollutants including the heavy metals and oil and grease build up to very high concentrations in the soil, and thereby seep or percolate into the groundwater, thereby posing great hazards to the people that consume the water, and also great hazards to the soil. The soil quality becomes compromised, thus posing challenges to groundwater due to seepage during the raining season. This not only affects the human population that depend on such water, but the soil fauna are equally decimated. Most of the heavy metals analysed and the level of their presence can hardly support soil animal life.

REFERENCES

American Public Health Association (1998).Standard Methods for the Examination of Water and Wastewater. 20th edition. A.P.H.A., Washington, D.C. p. 1134.

Association of Analytical Chemists (1975. Official Methods of Analysis of the Association of Analytical Chemists. A.O.A.C., Washington p. 232 (14.065).

Bayero A (2004).Environmental Degradation, Causes, Effects, Implications for Resource Conservation and the Future. In Environmental Degradation, Reclamation, Conservation and Pollution Control for Rural Women and the Youths. Proceedings of the National Training Workshop organized by The Environment and Development Action Plan for Women (EDAPW) and the Nigerian National Commission for UNESCO (NATCOM), UNAD, 24th-26th August, 2004. pp. 37-48.

Botkin DB, Keller EA (1997). Environmental Science. Earth As A Living Planet, 2nd Edition. John Wiley and Sons Inc., New York. p.649.

Dixon JB, Weed SB (eds) (1989). Minerals in Soil Environments. (2nd Edn). Soil Science Society of America. Madison

Elueze AA, Omidiran JO, Nton ME (2004). Hydrogeochemical Investigation of Surfacewater and Groundwater around Ibokun, Ilesha Area, Southwestern Nigeria. J. Mining Geol. 40(1):57-674.

FEPA (1991). National Guidelines and Standards for Water Quality in Nigeria. Federal Ministry of Environment. p.114.

Gupta UC, Gupta SC (1998).Trace Element Toxicity Relationship to Crop Production, Livestock and Human Health, Comm. Soil Science, Plant Anal. 29 (11-12):1491-1522.

"Ibadan." Microsoft® Encarta® 2009 [DVD]. Redmond, WA: Microsoft Corporation, 2008.

Jaiyeola OM (1999). Levels of Heavy Metals in Top Soils of Motor Parks, Mechanic Workshops, and petrol stations in Ibadan City. An Unpublished M.Sc Thesis.

Kamprath EJ (1970). Exchangeable aluminium as a criterion for

Liming Leached Mineral Soils. Soil Science Society of America Processing 34:252-354.
Ladunni OA (2004). The Impacts of Auto-mechanic Workshops on the Soil Environment. An Unpublished B.Sc Thesis.
Maduka HCC (2004). Water Pollution and Man's Health. In Environmental Degradation, Reclamation, Conservation and Pollution Control for Rural Women and the Youths. Proceedings of the National Training Workshop organized by The Environment and Development Action Plan for Women (EDAPW) and the Nigerian National Commission for UNESCO (NATCOM), UNAD, 24th-26th August, 2004. p.198.
Miller GT Jr (1988). Environmental Science: An introduction. 2nd Edition. Wadsworth Publishing Company. In: Okonkwo, G. E. (2000). Impact of Pepsi-7up Industrial Effluents on Surface Water (Alaro Stream). p. 407.
Okonkwo GE (2000). Impact of Pepsi-7up Industrial Effluents on Surface Water (Alaro Stream). An unpublished M. Sc. Thesis.
Oni AA (2000). Macrofaunal Diversity and Impact of Leechate from Landfills on Ground and Surface Waters in Three Locations in Ibadan. Unpublished M.Sc Thesis. p.113.
Tchobanoglous G, Scheider ED (1985). Water quality: Addison-Wasley Reading, MA.
Tijani MN (1994). Hydrogeochemical Assessment of Groundwater in Moro Area, Kwara State, Nigeria. Environ. Geol. 24:194-202. In Elueze AA, Omidiran JO, Nton ME (2004). Hydrogeochemical Investigation of Surfacewater and Groundwater Around Ibokun, Ilesha Area, Southwestern Nigeria. J. Mining Geol. Nigerian Mining and Geoscinces Society (NMGS). 40:1.
USEPA (1993). Handbook for Monitoring Industrial Wastewater.
Wild, A. (1995). Soils and the Environment: An introduction. University of Cambridge, Cambridge. pp. 189-204.

Appendix I. FEPA standards for water quality: Drinking water.

Parameter	Permissible limit standard
pH	6.5-8.5
DO (mg/L)	7.5
BOD (mg/L)	0
Turbidity (F.T.U)	1.0
Total suspended solids (mg/L)	>10
Total dissolved solids (mg/L)	500
Hardness (mg/L)	200
Nitrate (mg/L)	10.0
Phosphate (mg/L)	>5
Cadmium (mg/L)	0.01
Iron (mg/L)	1.0
Lead (mg/L)	0.05
Oil and grease (mg/L)	0.05

Appendix II. Natural effluent limitations and gaseous emissions guidelines in Nigeria.

Parameter	Limit for land application (mg/l)
Iron	0.20
Cadmium	0.01
Nickel	0.05
Copper	0.06
Lead	0.01
Cobalt	0.50
Arsenic	0.10
Zinc	3.0
Oil & Grease	10/0

Source: FEPA (1991).

Appendix III. Recommended maximum concentrations of metals in soils.

Parameter	Uncontaminated soil		Upper Limit	
	(mg/kg)	(kg/ha)	(mg/kg)	(kg/ha)
Zinc	80	160	300	600
Copper	20	40	135	270
Nickel	25	50	75	150
Lead	50	100	250	500
Cadmium	0.5	1	3	6

Assuming t ha^{-1} to 15 cm depth (Source: DOE/NWC, 1981).