JOURNAL OF PHYSICAL AND CHEMICAL SCIENCES

Journal homepage: http://scienceq.org/Journals/JPCS.php

Research Article Open Access

GIS Assessment of Heavy Metal Pollution in Groundwater around Agodi-Gate Automobile Station Ibadan, South-Western Nigeria

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Received: February 28, 2018, Accepted: March 04, 2018, Published: March 04, 2018.

ABSTRACT

This study assessed the extent of downslope movement of heavy metals from Agodi Gate automobile station in Ibadan using Geographic Information System (GIS). Well water (groundwater) samples were collected and analyzed to assess concentrations of lead (Pb), Nickel (Ni) and Chromium (Cr) using Atomic Adsorption Spectrophotometer. GIS was used to map and measure the lateral dispersal extents of those heavy metals from sources. Pb, Ni and Cr concentrations in soil samples decrease down the slope from 485-2mg/kg, 33-10mg/kg and 18-0.0mg/kg with dispersal extents of 269.09m, 321.66m and 240m, respectively. The heavy metals concentrations in the water samples however decrease down the slope from 0.25-0.00mg/l, 0.18-0.00mg/l and 0.00-0.00mg/l with Pb and Ni contamination extents of 61.78m and 131.66m, respectively. The order of heavy metals contamination degree is Pb>Ni>Cr while the order of heavy metals contamination extent is Ni>Pb>Cr.

Keywords: *Automobile Service Stations, Heavy Metals, Groundwater, Geographic Information System (GIS).*

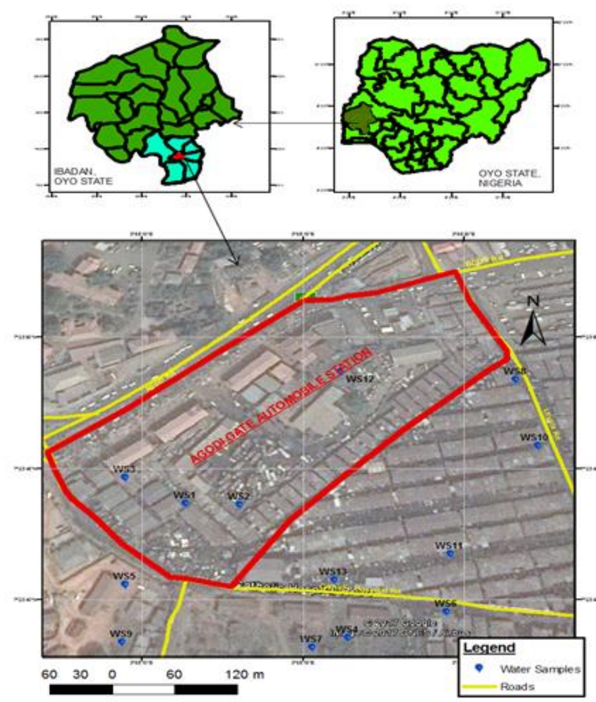
1. INTRODUCTION

The major pollutants emitted from mechanic villages include metals, hydrocarbon (HC), Volatile Organic Compounds etc. These pollutants have damaging effects on aesthetics, human health and ecology [1,14]. The human health effects of these pollutants vary in the degree of severity, covering a range of minor effects to serious illness, as well as premature death in certain cases. Most of the conventional pollutants are believed to directly affect the circulatory and cardio-vascular systems [4,6]. In particular, high levels of metals, HC and VOCs are associated with flora and fauna depleted and could be carcinogenic. Lead prevents hemoglobin synthesis in red blood cells, impair liver and kidney function and causes neurological damage [5,12].

Significant trace metal pollution of soil within and around mechanic villages coupled with continuous interactions between soil and water and high dispersion rate during rainy season implies that water bodies (surface and groundwater) within and at the vicinity of a mechanic village may equally be polluted with trace metals [10,13]. Heavy metals toxicity, persistent and non-degradable attributes in the environment have made them dangerous pollutants [2,9].

A study of the distribution of heavy metals in groundwater within and around mechanic workshops is particularly important as the significance of trace heavy metals such as lead, nickel and chromium, in groundwater chemistry is increasingly becoming an issue of global concern [7,8]. GIS spatial assessment of the movement of pollutants from automobile stations gives a clear and better understanding of the impacts made by the pollutants. This subsequently helps in the effective management of pollutants. GIS software allows complex spatial attributes such as groundwater data, elevation data as well as soil data to be represented, modeled, quantified, interpolated, analyzed, measured and assessed [3,11]. This study utilizes GIS to evaluate the extent of movement of heavy metals (lead, nickel and chromium) from Agodi Gate automobile Station.

2. Study Area



Gate mechanic village, located on longitude 07.08053^0N and latitude 003.29818^0E, is the largest automobile station in Ibadan city. It was established in the year 1964. Work in the village involves dismantling, repairing, reassembling, reforming and selling of vehicles. The number of workshops within this mechanic village is over 200. There are nine (9) groups of workshop, each group with different activities which include; battery chargers, auto electricians, mechanics, blacksmiths and welders, vulcanizers, spring painters, panel beaters, rewires and part sellers. Most of their working tools and reagents are spanner, hammer, cambered, oil, petrol, diesel, paint, iron, steel etc. Thirteen (13) hand-dug wells within 0-200m from the village were identified and selected for analysis. The 13 hand-dug wells were given codes and their locations is as shown in Figure 2.1. Wells WS1, WS2 and WS3 are within the village while other wells are outside the village.

3.Methodology

A water sample each was obtained from the 13 hand-dug wells within 0-200m from the mechanic village down the slope. Each water sample was individually collected into rinsed 1L plastic bottle, with cap securely tightened. Water samples collection was done once during the rainy season when there is high rate of movement of the pollutants (heavy metals). The coordinates of sample collection points were also taken and recorded using Germin Handheld Geographical Positioning System 12 XL.

The 13 water samples were taken to the laboratory to determine the concentration of lead, nickel and chromium in each sample. Determination of heavy metal concentration was done using Atomic Adsorption Spectrophotometer (AAS Model 210 VGP) after calibrating the equipment with different standard concentrations. GIS was used to model and spatial distribution of analyzed heavy metals. The inputs used for generating heavy metal distribution maps were the longitudes and latitudes of groundwater samples collection points as well as the laboratory results of concentration of heavy metals in the groundwater. Inverse Distance Weighted (IDW) method of interpolation was used to generate the heavy metals distribution maps. The distances moved by heavy metals from source were also measured within the GIS environment. Distance icon within the GIS interface was used for the spatial analyses. The flowchart used in this study is presented in Figure 3.1

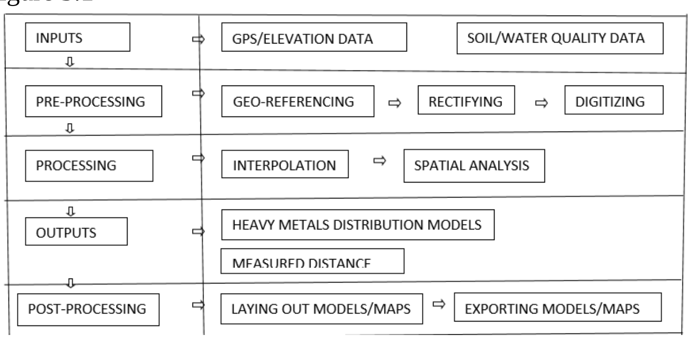


Figure 3.1: Flow-Chat Showing Heavy Metal Distribution Modeling Process

RESULTS AND DISCUSSION

4.1 Results

Table 4.1 shows the results of the AAS analysis performed on the water samples. The concentrations of Pb, Ni and Cr in the water samples are from 0.00-25mg/l, 0.00-0.18mg/l and 0.00-0.00mg/l respectively. The permissible values of Pb, Ni and Cr according to WHO standardare 0.01mg/l, 0.02mg/l and 0.05mg/l respectively. The results of the analysis when

compared with WHO standards shows that wells WS1, WS2, WS3 and WS12 are above Pb permissible level while wells WS1, WS2, WS3, WS4, WS7, WS9, WS11, WS12 and WS13 are above Ni permissible levels. This shows that Nickel have the highest frequency of contamination, contaminating nine of the thirteen wells. The absence of Cr in the water samples is perhaps as a result of little or no usage of chromium related materials and solvents in the village. On the contrary, the presence of Pb and Ni in the water samples is due to factors such as high usage of Pb and Ni as metal coats and wires, as anti-knock agents in gasoline and as additives in paints and solvents. Pb and Ni, due to their relatively small sizes also have the ability to percolate in underlying groundwater when added by water

4.2 Heavy Metals Distribution

Table 4.1 Water Samples Laboratory Results of Heavy Metals

S/N	WELL CODE	LONGITUDE $(^0)$	LATITUDE $(^0)$	Pb (mg/l)	Ni (mg/l)	Cr (mg/l)
1	WS1	3.921041	7.394175	0.24	0.07	0.00
2	WS2	3.921300	7.394200	0.25	0.18	0.00
3	WS3	3.920500	7.394300	0.14	0.06	0.00
4	WS4	3.922771	7.393111	0.00	0.07	0.00
5	WS5	3.921000	7.393700	0.00	0.00	0.00
6	WS6	3.922800	7.393200	0.00	0.00	0.00
7	WS7	3.922500	7.392800	0.00	0.04	0.00
8	WS8	3.922700	7.395700	0.00	0.00	0.00
9	WS9	3.920783	7.392877	0.00	0.12	0.00
10	WS10	3.923143	7.394944	0.00	0.00	0.00
11	WS11	3.923065	7.393892	0.00	0.04	0.00
12	WS12	3.921660	7.395310	0.12	0.05	0.00
13	WS13	3.920380	7.392685	0.00	0.05	0.00

Figure 4.1 shows the distribution of lead in groundwater at Gate Mechanic Village. The concentration of lead at the village, was observed to reduce eastward down the slope. The lead distribution shows that other wells outside the village have no record of lead contamination. The concentrations of lead are extremely high at WS1 and WS2 with range of 0.201-0.025mg/l. This is because they are situated in the heart of the Mechanic Village where heavy metal waste generation is high. Presence of lead in the groundwater explains that automobile heavy metals wastes are capable of percolating from the topsoil into the subsoil and subsequently to the underlying groundwater resources. These cause serious depletion of the groundwater qualities and are dangerous to human health. From the groundwater lead distribution map, it is suggested that wells should be sited at a minimum downhill distance of 80m away from the village to avoid lead contamination. The range of lead contamination is 0.08-0.25mg/l with lateral dispersal extent of 61.78m.

Figure 4.2 shows the distribution of nickel in groundwater at Gate Mechanic Village. The concentrations of nickel at the mechanic village groundwater were observed to be spread almost throughout the entire study area except four wells (WS5, WS6, WS7 and WS8) that are not contaminated with nickel. WS2 shows the highest nickel concentration (0.18mg/l). This is possibly due to the high usage of nickels materials and products at that section the village. The range of nickel contamination is 0.04-0.18mg/l with lateral dispersal limit of 131.66m. This reveals that nickel disperse easily and farther in water as compare to lead. It is therefore recommended that there should be reduced usage of nickel products and materials because of its high mobility.

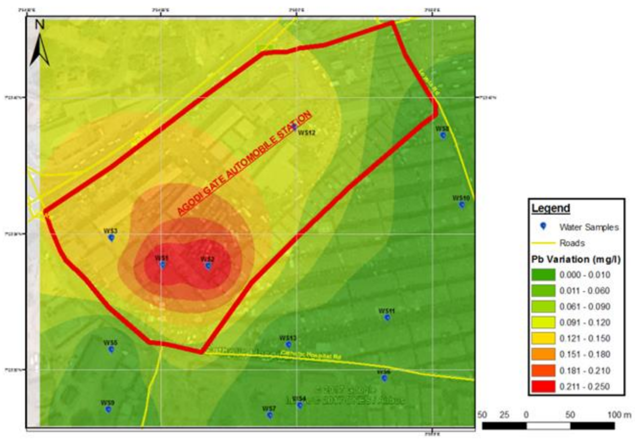


Figure 4.1: Distribution of Lead in Groundwater at Gate Mechanic Village

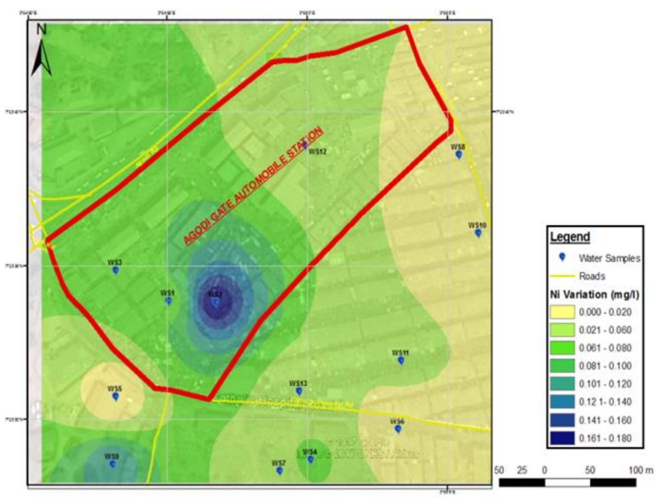


Figure 4.2: Distribution of Nickel in Groundwater at Gate Mechanic Village

5.CONCLUSIONS AND RECOMMENDATIONS

Heavy metals wastes from mechanic workshops are posing serious ubiquitous problem to groundwater resources. Among the heavy metals analyzed. Pb and Ni are major elements of concern. The elements have the highest pollution degrees and extents. High concentrations of Pb and Ni at the automobile stations soils and groundwater are as result of significant usage of Pb and Ni products and materials within the station. The order of heavy metals contamination is Pb>Ni>Cr and the extent is Ni>Pb>Cr. There should be reduced usage of nickel batteries, products and materials by automobile technicians, because it has been discovered that nickel is capable of polluting the environment with great vertical and lateral extent. Wells within these mechanic villages should be used strictly for household consumption. They should not be consumed as they are not drinkable. Wells intended for consumption should be located 150m away from the automobile station.

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Citation: Akolade, Adebola Saheed et al. (2018). GIS Assessment of Heavy Metal Pollution in Groundwater around Agodi-Gate Automobile Station Ibadan, South-Western Nigeria. j. of Physical and Chemical Sciences.V6I2-03. DOI: 10.5281/zenodo.1212843