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Assessment of Impact of Dumpsite Leachate on Natural Waters in Abakaliki, Southeastern Nigeria

Ozoko Daniel Chukwuemeka* & Iwe Paul Uchenna
Department of Geology and Mining, Faculty of Applied Natural Sciences, Enugu State University of Science and Technology, Agbani, Enugu, Nigeria
dan.ozoko@gmail.com

Abstract
This work was carried out to determine groundwater and surface water pollution resulting from indiscriminate waste deposit using organic and heavy metals parameters on Abakaliki dumpsite. Abakaliki and environs lies between latitudes 6^o 17''N and 6^o 22''N longitudes 8^o 04''E and 8^o 8''E and underlain by Abakaliki Formation which is made up of an alternating succession of dark shales and sandy- shales. In the study area, it dips 4^0-8^0 in the SW direction. A total of twenty [20] water samples were collected from dumpsite at varying distance away from the dumpsite. Laboratory examination of water samples involved analysis of organic contaminants (Ammonia-Nitrogen, Diethylphthalate, Total Organic Halogen, 2,4-dichlorophenol, Nonylphenol Ethoxylate, Methyl Ethylphthalate, Borneol, Total Kjeldah) and heavy metals (Mn, Fe, Pb, As, Cd, Cr, Ni) were analyzed in accordance with standard procedures. Results of laboratory analyses indicate that the average values of diethyl–phthalate, borneol, TOH, nonylphenol–ethoxylate and TOC are 0.92 µg/l, 1.324 µg/l, 0.955 µg/l, 1.559 µg/l and 6.4 µg/l, respectively for groundwater and 0.34 µg/l, 1.334 µg/l, 1.277 µg/l, 1.296 µg/l and 8.3 mg/l, respectively, for rivers. The heavy metal concentrations occur in the following order of abundance; Zn > Fe > Mn > Pb > Cd>As. Consumption of domestic water sources within the dumpsite area, in untreated state, could lead to health risks as these organic contaminants and heavy metals are mostly carcinogenic, toxic and injurious to human systems.

Keywords: Abakaliki dumpsite. Heavy metals. Leachate water. Spatial distributions.

1. Introduction

Human-mediated activities and processes have a tendency to generate large amounts of waste, which can range from recyclable and non-recyclable to very harmful wastes (Adekunle et al, 2011). The way that these wastes are gathered, treated, kept, handled, and discarded of, however, raises concerns to both the environment and public health (Amadi et al., 2012, Ugwuishiwu et al., 2016). The problems with solid waste management in urban areas, especially in fast growing cities like Abakaliki are of great concern. Household waste is typically disposed of in uncontrolled and poorly managed dumpsites, streams, street collections and along drainage systems in most developing nations (Akinbile and Yusoff, 2011).

In impoverished cities like Abakaliki, the most prevalent technique of waste management is unhygienic waste disposal, especially open-air tipping dumpsites (Anikwe and Nwobodo, 2001). Inadequate bottom liners, leachate collection systems, and waste treatment facilities hinders the effective handling of metropolitan solid wastes from occurring in many non-engineered, unregulated dumpsites (David and Oluyege, 2014). This has resulted in the production of dumpsite leachates, which include considerable amounts of inorganic and organic pollutants and pose a major threat to the environment. Leachates vary in composition, but the majority contain xenobiotic organic components, highly pathogenic bacteria, developing organic pollutants, heavy metals, and other inorganic chemicals (Njoku, 2014).

Abakaliki today is experiencing rapid growth of population and industrialization. These massive population and industries generate tons of municipal solid wastes per day but unfortunately, there is no treatment and disposal facility for the management of the wastes from these areas. These wastes are disposed in a disorganized manner, at Abakaliki central dumpsite. The major dangers associated with this poor handling of municipal solid waste is the possibility of releasing toxic metals into the environment, therefore, posing serious threats to nearby lands and groundwater, and then to surface water. Hence, aim of the present work is to examine the organic contaminants and heavy metals concentration in natural waters around Abakaliki dumpsite.

2. Materials and method

2.1 Study Area

The study was conducted in Abakaliki, Ebonyi State, South-eastern Nigeria (Figure 1). The geographical coordinate lies within latitudes 5°45'0''N-6º45'0''N and longitudes 7º40'0''E - 8° 30'0''E (Figure 1) and falls within the Southern Benue Trough which has a catchment area of about 203,000km^2. Abakaliki occupies the eastern axis of Ebonyi state, covering a land area of about 584 km^2. It is bounded to the east by the Cross River State and to the west by Enugu State. The northern boundary is demarcated by Benue State and the southern boundary by the Abia State. Abakaliki and its environs are generally characterized by flat topography due to the underlying geology with very few elevated points resulting from post tectonic activities in the area which led to the formation of few conical hills. The highest elevation in the study area is represented by the popular hill which is about 150 m above sea level. The study area has a hot and humid climate and day-time temperature ranging from 28º to 35ºc, while night-time temperature ranges from 18º to 28ºc. Two main climatic changes occur in the area; the rainy and dry seasons (Illeje, 1974). The area lies within the tropical rainforest belt of Nigeria (Igbozuruike, 1975).

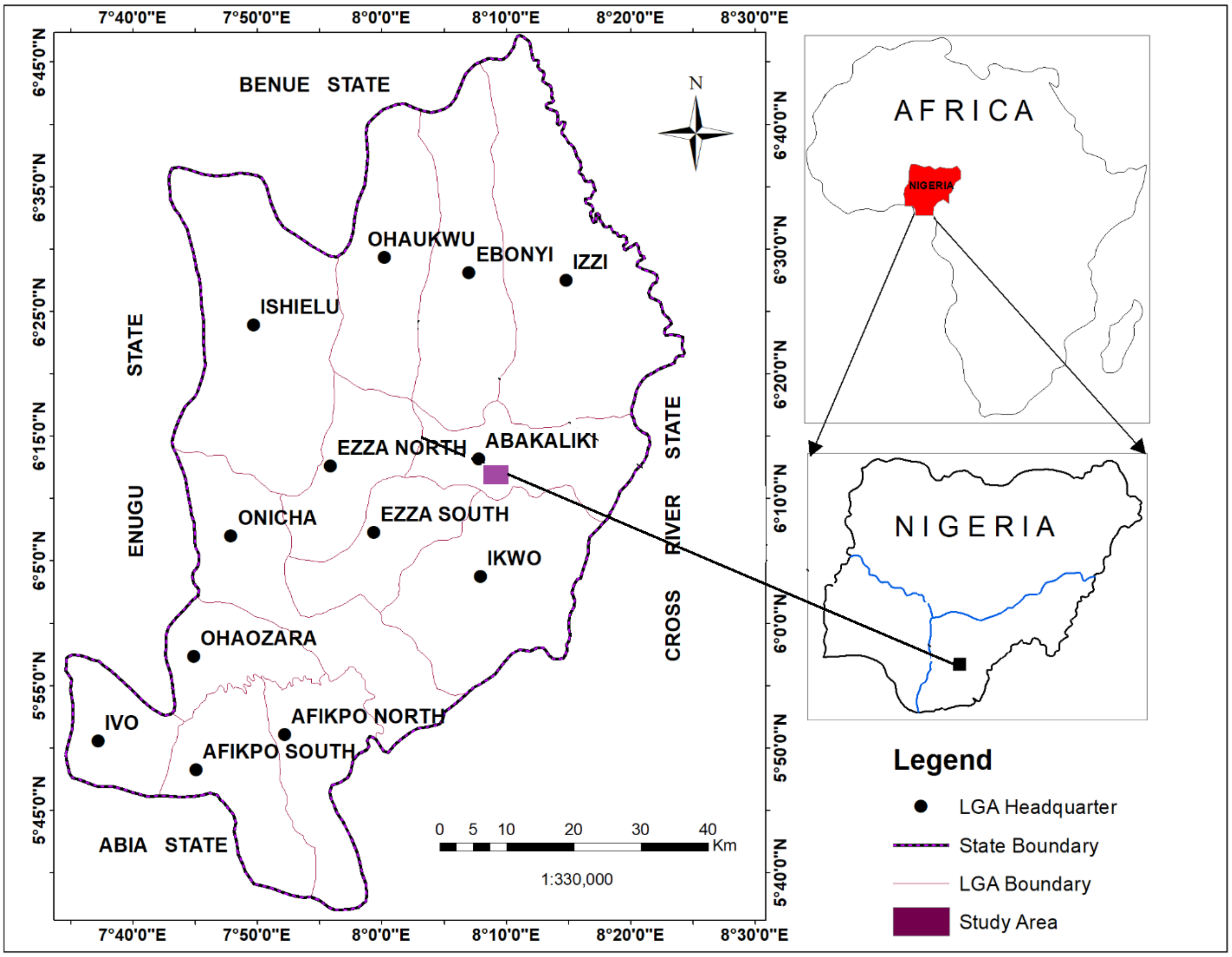

Figure 1: Location map of the study area

2.2 Geology and Hydrogeology of the Study Area

The study area is underlain by Abakaliki Formation (Figure 2) which is consists of poorly bedded shale, occasionally sandy, with lenses of sandstone and mudstone. The sediments are associated with lead-zinc mineralization, are folded and the fold axes stretch NE-SW. The shales are baked, dark-grey, fissile, compacted, highly folded, fractured and faulted (Agumanu, 1985).

Aquifer system of the area is characterized by unconfined aquifer system which formed from weathered, fractured and jointed shales of Abakaliki Formation. Investigations reveal that the inhabitants of Abakaliki and environs tap their water through numerous streams and hand-dug wells from the material under investigation. Estimated depth of these wells is about 10 to 15 meters [33 to 49ft] and most of these are perennial.

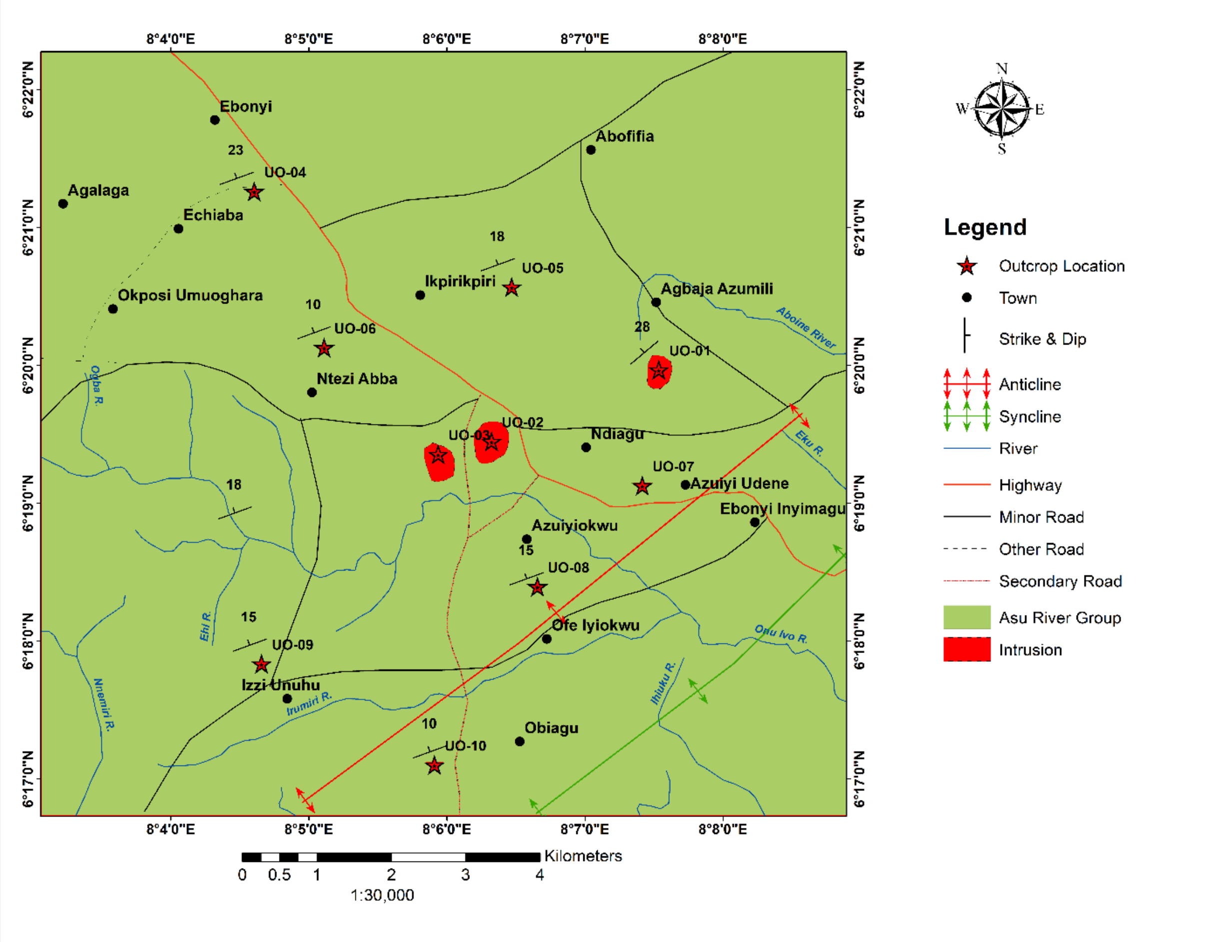

Figure 2: Geological map of the study area

2.3 water Sampling Collection

Water samples were collected from twenty [20] sampling locations (Figure 3). Two [2] samples were from leachate waters located within the dumpsites, fourteen [14] shallow groundwater samples collected at different distances away from the dumpsite and the other four [4] samples were collected from surface waters located within study area with 1liter plastic containers. The sample bottles were rinsed three times with deionized water before use. At every sampling site, the bottles were properly rinsed with the water to be sampled prior to collection, tightly closed leaving air bubble below the stopper, labelled properly and stored in cooler. The samples were thereafter sent to laboratory for organic contaminants and heavy metals analysis immediately after collection. The selected organic contaminants (Ammonium-nitrogen, total organic halogen (TOH), 2-4, dichlorophenol, nonylphenol ethylxylate, methyl ethyl phthalate, borneol, and diethyl phthalate) and heavy metals (Fe, Zn, Cu, Cd, Pb, As, Cr, Ni, and Mn) were analyzed in the laboratory. The detection of traced metals in the environment are accomplished by various methods but here the UV-Visible Spectrophotometer and atomic absorption spectrophotometer (AAS BULK SCIENTIFIC MODEL 210 VGP) technique were used.

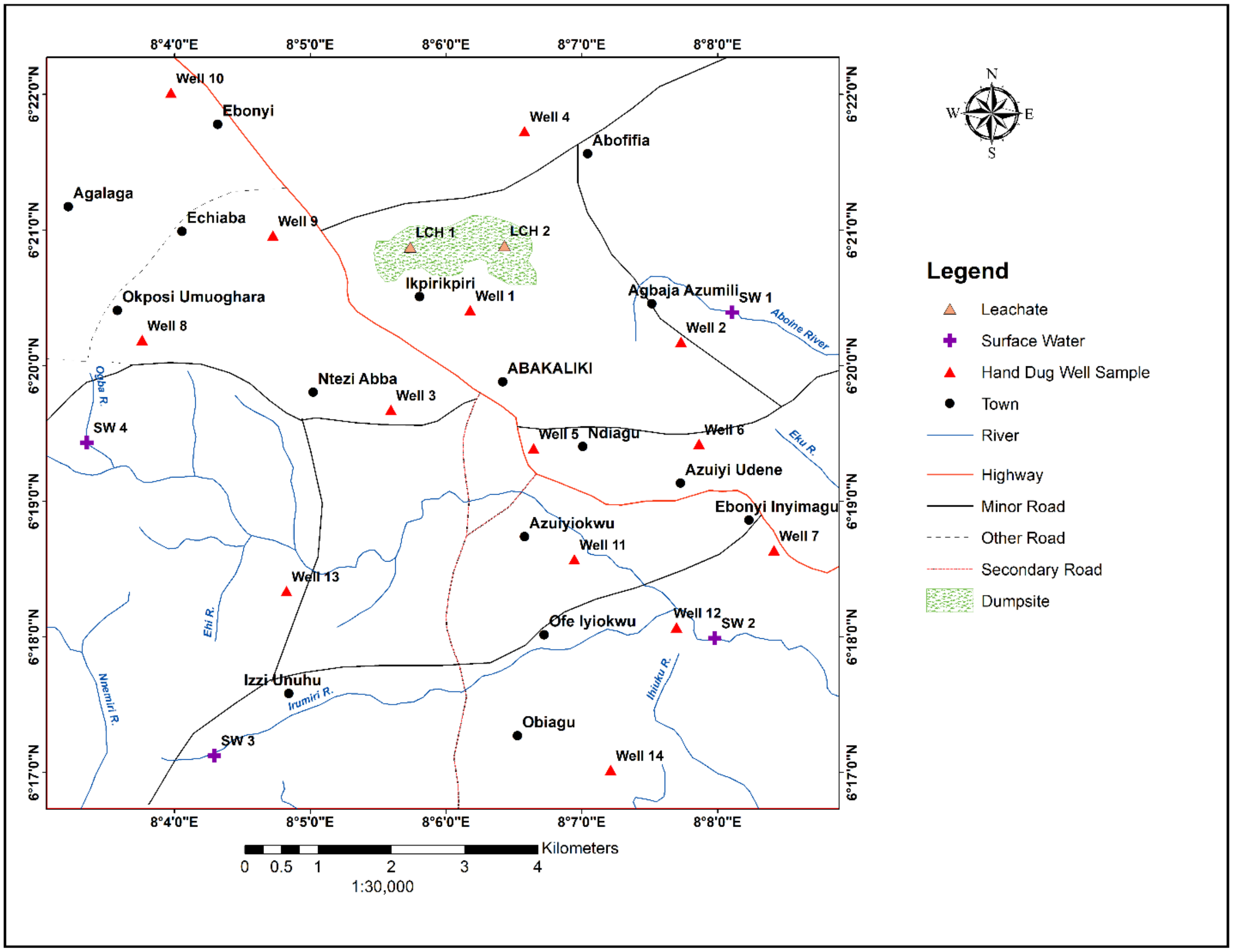

Figure 3: Sample map of leachates, surface waters and hand dug wells in the study area.

3. Results and Discussion

3.1 Organic contaminants level

The results of organic contaminants level in the leachate, hand dug wells and surface water quality from within/around the Abakaliki dumpsite is revealed in Table 1.

Ammonia Nitrogen, Diethylphthalate, Total Organic Halogen, 2,4-Dichlorophenol, Nonylphenol Ethoxylate, Methyl Ethoxylate, Borneol, and Total Kjeldah levels varied between 0.18 and 0.96, 0.029 and 1.986, 0.338 and 1.334, 0.014 and 1.909, 0.009 and 0.038, 1.04 and 6.04, 2.4 and 10.8, and 0.020 and 0.099. As indicated in Table 1, the amounts of total organic halogen, ammonia nitrogen, and diethylphthalate were all significantly greater in leachate samples than other samples collected from hand dug wells and surface water samples at different distances away from the dumpsite. This suggests that total organic halogen levels in samples taken from the leachate and the dumpsite had reached an unhealthy level. The disinfectants and plastic wastes placed at the site were the source of high borneol concentrations discovered in leachate samples and shallow hand-dug wells close to the dumpsite. Due to the anaerobic conditions that exists in the dumpsite, high ammonia-nitrogen concentration in the leachate samples may accelerate the transition of nitrate into ammonia gas phase and this can lead to eutrophication and dissolved oxygen depletion in natural waters. High levels of diethylphthalate in the leachate samples is an indication of high disposal of insoluble wastes, especially plastics of all kinds, fragrances, insecticides, and abandoned water cans.

Table 6.3: Results of organic contaminants measured in the study area

Location	Sample ID	NH_4NO_3 (µg/l)	$C_{11}H_{12}O_4$ (µg/l)	TOH (µg/l)	$C_{10}H_{18}O$ (µg/l)	$C_{12}H_{14}O_4$ (µg/l)	$C_6H_4C_{12}O$ (µg/l)	$C_{15}H_{24}O$ (µg/l)	KN (µg/l)
Ikpirikpiri	LCH 1	0.82	1.986	0.338	1.599	0.038	2.02	7.5	0.099
Ikpirikpiri	LCH 2	0.96	1.324	0.977	1.909	0.037	3.11	9.5	0.037
Ikpirikpiri	Well 1	0.92	1.027	0.955	1.599	0.026	4.01	6.4	0.092
Abione river	SW 1	0.34	1.334	1.277	1.296	0.020	2.27	8.3	0.058
Agbaja Azumili	Well 2	0.28	0.352	0.335	1.268	0.015	3.09	6.6	0.055
Ntezi Abba	Well 3	0.18	0.029	0.980	1.012	0.019	1.18	3.1	0.023
Abofifia	Well 4	0.39	0.339	1.328	0.639	0.010	3.11	10.8	0.032
Ndiagu	Well 5	0.30	0.352	0.987	0.329	0.018	5.06	6.2	0.047
Azuiyi Udene	Well 6	0.20	0.985	1.334	0.977	0.009	3.20	5.3	0.039
Ebonyi Inyimagu	Well 7	0.26	0.658	1.296	0.373	0.011	6.04	4.2	0.060
Okposi Umuoghara	Well 8	0.22	1.268	0.952	0.983	0.013	4.06	6.7	0.061
Echiaba	Well 9	0.23	1.268	0.569	0.639	0.009	4.10	3.3	0.062
Ebonyi	Well 10	0.19	0.686	0.980	0.983	0.023	4.01	7.1	0.020
Ogba River	SW 2	0.28	1.015	1.303	1.268	0.020	2.02	4.2	0.022
Irumiri River	SW 3	0.33	0.683	0.689	0.718	0.027	1.04	4.8	0.070
Azuiyiokwu	Well 11	0.27	0.674	1.303	0.027	0.025	1.17	3.4	0.067
Ogba River	SW 4	0.25	1.628	0.538	0.014	0.020	2.09	7.1	0.046
Ofe Iyiokwu	Well 12	0.23	0.392	0.968	0.018	0.022	2.18	4.0	0.074
Izzi Umuhu	Well 13	0.21	0.952	0.369	0.015	0.018	4.12	2.4	0.031
Obiagu	Well 14	0.36	0.332	0.661	0.018	0.010	1.70	6.5	0.026

3.2 Heavy metals concentration

The results of the leachate, hand dug wells and surface waters quality from within/around the Abakaliki dumpsite is presented in Table 2. These metal concentrations were compared with recommendations for drinking water quality (or standards) stipulated by WHO, (2017) and NIS, (2007) respectively.

Table 2: Results of heavy metals of leachate, surface waters and hand dug wells in the measured sample

Location	**Sample ID**	**Mn (mg/l)**	**Fe^{3+} (mg/l)**	**Pb (mg/l)**	**As (mg/l)**	**Cd (mg/l)**	**Cr (mg/l)**	**Zn (mg/l)**	**Ni (mg/l)**
Ikpirikpiri	LCH 1	3.61	5.60	0.35	0.07	0.03	0.12	10.63	2.11
Ikpirikpiri	LCH 2	3.47	4.81	0.40	0.08	0.05	0.12	10.19	1.76
Ikpirikpiri	Well 1	1.01	2.69	0.21	0.03	0.02	0.09	6.37	0.19
Abione river	SW 1	0.33	1.42	0.11	0.04	0.02	0.06	4.51	0.08
Agbaja Azumili	Well 2	0.18	0.61	0.01	0.02	0.01	0.05	3.86	0.06
Ntezi Abba	Well 3	0.12	0.23	0.01	0.04	0.01	0.05	2.10	0.04
Abofifia	Well 4	0.11	0.33	0.02	0.01	0.02	0.01	3.09	0.02
Ndiagu	Well 5	0.16	0.35	0.00	0.02	0.005	0.03	4.11	0.01
Azuiyi Udene	Well 6	0.19	0.44	0.03	0.02	0.01	0.02	1.76	0.01
Ebonyi Inyimagu	Well 7	0.18	0.62	0.01	0.03	0.003	0.05	2.54	0.07
Okposi Umuoghara	Well 8	0.16	0.37	0.00	0.00	0.02	0.002	2.10	0.03
Echiaba	Well 9	0.08	0.31	0.05	0.00	0.00	0.01	1.22	0.01
Ebonyi	Well 10	0.06	0.54	0.02	0.00	0.002	0.01	4.15	0.02
Ogba River	SW 2	0.10	0.46	0.06	0.03	0.01	0.04	1.18	0.04
Irumiri River	SW 3	0.17	0.31	0.03	0.02	0.004	0.05	3.36	0.02
Azuiyiokwu	Well 11	0.10	0.28	0.00	0.01	0.02	0.03	2.94	0.02
Ogba River	SW 4	0.12	0.23	0.03	0.02	0.003	0.03	6.27	0.07
Ofe Iyiokwu	Well 12	0.05	0.11	0.01	0.00	0.01	0.01	1.22	0.03
Izzi Umuhu	Well 13	0.08	0.19	0.01	0.00	0.01	0.05	3.13	0.01
Obiagu	Well 14	0.10	0.20	0.00	0.00	0.001	0.02	1.84	0.01
WHO (2017)		**0.4**	**0.3**	**0.01**	**0.01**	**0.003**	**0.05**	**4**	**0.07**
NIS (2007)		**0.2**	**0.3**	**0.01**	**0.01**	**0.003**	**0.05**	**3**	**0.02**

Mn and Fe^{3+} concentrations within the examined water samples ranged between 0.05 to 3.61 mg/l and between 0.11 to 5.60 mg/l. The acceptable limit of manganese and iron in water is 0.4 and 0.3 mg/l according to WHO (2017), 0.2 and 0.3 mg/l according to NIS (2007). Just as expected, the highest concentrations of Mn and Fe^{3+} were observed in leachate samples obtained from a hole dug inside the dumpsite (LCH 1 and LCH 2). The high manganese and iron levels observed in the leachate water samples may be due to high content of iron-based waste materials been generated through domestic and industrial wastes. Figure 4a displays that Mn forms a plume only within the dumpsite. Apart from the leachates, a significant high concentration of Mn was found in a hand-dug well located very closed to the dumpsite (Well 1) while Ofe Iyioku sample (Well 12) which is far away from the dumpsite had the lowest Mn concentration. A comparison of the distances and concentrations of heavy metals in the study area would suggest that there was a general attenuation of Mn and Fe^{3+} away from the dumpsite. The observed attenuation could be brought by dilution, filtration, and aeration over time and distance.

The results of the lead (Pb) and arsenic (As) of the examined samples are presented in Table 1, while the spatial distribution in concentrations of the metals is revealed in Figure 4b and c. Lead and arsenic levels in the tested water samples varied from 0.00 – 0.40 mg/l and from 0.00 – 0.08 mg/l. The stipulated limit of lead and arsenic in water is 0.01 and 0.01 mg/l based on WHO (2017), and NIS (2007). The concentrations of Pb and As analyzed in the leachate samples were generally higher (highest in the sample collected inside the dumpsite) compared to shallow hand-dug wells and surface water samples. It could possibly be attributed to the high levels of lead and arsenic in the pharmaceutical wastes, empty detergents containers, and other municipal and industrial wastes being dumped in the dumpsite.

The results of cadmium and chromium analysis on the samples are presented in Table 1, while the spatial distribution concentration data are displayed in Figure 4d and e. The concentration of these metals in the study area ranged from 0.00 – 0.05 mg/l and from 0.002 – 0.12 mg/l. The standard limit of cadmium and chromium in water is 0.003 and 0.05 mg/l according to WHO (2017) and NIS (2007). The highest values of the two heavy metals were both measured in leachate samples.

Smith et al., (1995) had presented a series of possible sources of cadmium and chromium in leachates to include releases from electroplating processes and the disposal of Cd and Cr wastes. Thus, the substantial quantity of used cans of these products at the dumpsite would indicate the presence of these metals in the dumpsite leachates.

As revealed in Table 1, the zinc (Zn) and nickel (Ni), in a similar pattern, were both higher in the leachate samples in comparison with the other sample types (see Figure 4f). The water samples contained Zn and Ni concentrations in the range of 1.18 – 10.63 mg/l and 0.01 – 2.11 mg/l. The permissible limit of zinc and nickel in water is 4 and 0.07 mg/l according to WHO (2017), 3 and 0.02 mg/l according to NIS (2007). High concentrations of Zn and Ni in the leachate water samples would imply high toxicity for microorganisms that live within the dumpsite.

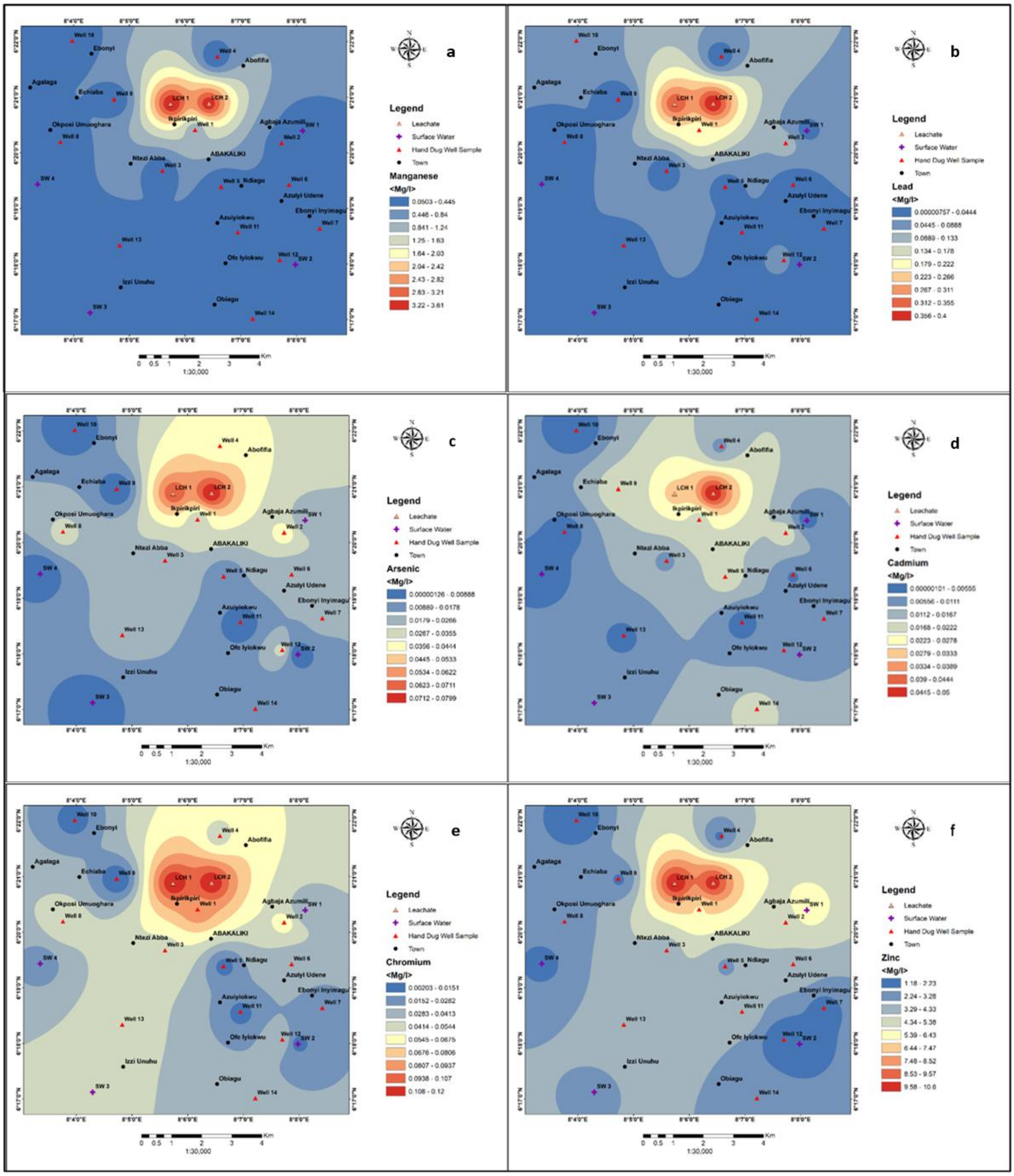

Figure 4: Spatial distributions of (a) Manganese (b) lead (c) arsenic (d) cadmium (e) chromium and (f) zinc in the analyzed water samples.

4. Conclusion

This study showed that natural water samples from within/around Abakaliki dumpsite, Southeastern, Nigeria contained organic contaminants and heavy metals depending on the distances away from the dumpsite. Of the samples examined, the concentrations of organic contaminants and heavy metals in the leachate water samples were higher than those obtained from hand dug wells and surface water samples. The levels of Mn, Fe^{3+}, Pb, As, Cd, Cr, Zn and Ni in shallow well samples were within the allowable limits set by WHO and NIS except Ikpiripkiri (Well 1), Abione River (SW 1), and Agbaja Azummili (Well 2). All the leachate water samples recorded metal values higher than the recommended values established by WHO and NIS. Tons of industrial and municipal garbage created in Abakaliki metropolis presented a possible conduit for metallic contaminants leached into some of the hand dug wells and the Abione River. As a result, there is a need to develop and implement regulations, strong standards, and other measures that will result in excellent waste management and treatment infrastructure, hence reducing environmental pollution and its related health risks. Residents residing near the dumpsite should be made aware of the potential health risks associated with untreated waste ingestion through public education and awareness initiatives.

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