



Assessment of injection well (IWs) as a measure of flood control

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Abstract

The study examined the reliability of injection wells (IWs) as a control measure of flood and flood-related activities considering the relevance and the role of groundwater to human and industrial activities. Seventeen Boreholes (BHs) including one as control, and three IWs in Government Reservation Area (GRA), Benin Metropolitan City (BMC) were used for the study. Groundwater flow and geospatial maps for the study area, and other parameters were generated and modelled using sufer15 2D modelling software in addition to correlation analysis. The parameters include pH, Turbidity, Lead (Pb), Nickel (Ni), Chromium (Cr), Iron (Fe), Coliform and *E. coli* Counts. The results showed that Pb in BHs BH8, BH9, BH3, BH4, BH5, BH12, BH15 BH16; Ni in BH5 and BH16; Cr in BH3 and BH15; Fe in BH4 and BH16 and the three IWs do not meet the required limit of 0.01, 0.02, 0.05 and 0.3 mg/L set by Nigeria Standard for Drinking Water (NSDWQ) and World Health Organization (WHO). All BHs and IWs were severely polluted with *Coliform* Count with the highest value of 22000 cfu/100 mL in IW1 and lowest of 360 cfu/100 mL in control BH17 against 0 cfu/100 mL recommended in potable water by regulatory agencies. Correlation at $P < 0.01$ two-tailed together with geospatial maps indicates that IWs influences the quality of groundwater source in the area. Based on the finding in this study, IWs as control measures for flood and flooding-related activities can only be applied when the aquifer geometry is known otherwise, it should be discouraged.

Keywords Environmental hazards · Groundwater protection · Potable water · Control measure and groundwater movement

Introduction

Globally, flooding is one of the greatest environmental/geologic hazards facing most urban cities with the highest impact around developing countries and some developed countries like the United State of America (Henry 2006; Eves and Wilkinson 2014; Associated Programme on Flood Management 2016; Amadeo 2020). It is usually caused by human interference with nature such as construction on natural paths and flood plains, desertification and the use of fossil fuel, global warming, and climate change as reported by the National Aeronautics and Space Administration (NASA 2020), World Health Organization (2020). Flooding and flood-related activities are induced by the growing

population and quest for technological advancement (United Nations 2011; Omorogieva and Andre-Obayanju 2020). It has caused a lot of damages globally; for example, between 1980 and 2013, a period of 37 years, the United States of America (USA) lost about \$260 billion to flood-related damages with an estimated \$1 billion in 2019 besides several deaths recorded (Hue et al. 2019; Hudson et al. 2019; Federal Emergency Management Agency (FEMA 2020), Amadeo 2020), National Oceanic and Atmospheric Administration (NOAA 2020). Apart from socio-economic impact, flooding also affects soil and water quality, consequently leading to shortage of land for agricultural activities; potable water quality for industrial and domestic uses (Hammond et al. 2013; Ogieriakhi 2019; Sieg et al. 2019).

Several measures have been adopted in the control of flood; these methods include the use of trapping and storing of carbon IV oxide, solar and wind energy, afforestation, the use of impounded wells, and construction of dams (Green et al. 2000; Pahlow et al. 2008; Associated Programme on Flood Management 2016; BBC 2021). These methods have yielded a positive result in the management and control of flood. However, the use of Underground Injection Control

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(UIC) also refer to as Injection Well (IW) as a traditional method of flood control in developing countries like Nigeria to check the menace caused by flooding is worrisome because flood waters contains hazardous contaminants and deleterious metal capable of contaminating groundwater resource (USEPA 1991; Alile et al. 2012; Sasakova et al. 2018; Ogieriakhi 2019; Conserve Energy Future 2020; Li et al. 2021). Groundwater contamination is one of the leading causes of death globally because of its dependence for drinking purpose, agricultural and industrial activities (Isabel 2018; Adimalla et al. 2020; Li et al. 2021). Its occurrences and distribution are restricted to some geological formations and structures known as aquifers (Fetter 2007; Toth 2020). Groundwater needs to be protected but the use of IWs as a method of flood control permits direct introduction of contaminants into the aquifer, and consequently contaminates groundwater thereby creating more problem for humanity. Against this backdrop the study was necessitated to assess the gap and possible effects of using IWs as flood control, and make recommendations for improvement. Basic parameters like pH, turbidity, heavy metal such Lead (Pb), Nickel (Ni), Chromium (Cr), and Iron (Fe) of known health impact as well as *E. coli* and Coliform Counts were measured in boreholes and the IWs in a flood-prone environment to achieve the aim of the study.

Metal like Pb has been reported in literature as the main cause of low intelligent quotient (IQ) in children less than 5 years of age, reproductive disorder, brain damage, and cardiovascular disease (Water Stewardship Information Series 2007; WHO 2012; Hime et al. 2015). Nickel and Chromium are known for respiratory failure, cancer, birth defects, and blood pressure according to the report of the Agency for Toxic Substances and Disease Registry (ATSDR 2012; Dai et al. 2017). Excess Fe intake in water can cause varied health issues like gene mutation, joints pain, weight loss, and hemochromatosis; a severe disease that damages the body organs (Searle et al. 2001, Omorogieva 2018; <https://www.livestrong.com/article>). Conversely, the presence of *Coliform* and *E.coli* counts in groundwater is a strong indication that the quality of the groundwater have been compromised as a result of anthropogenic rather than geogenic activities (Mukhejee and Nilliyat 2007; Imasuen and Omorogieva 2013a, b; Omorogieva and Imasuen 2018; Groundwater Foundation 2020). Storm water carries contaminants from various sources to flood-prone areas where they become a source of groundwater recharge either through natural process by percolation or by anthropogenic process through IWs (Singh and Kaur 2003; Harter 2020). Shallow unprotected aquifers within the range of 0–60 m may become vulnerable to groundwater contamination as result of storm water being introduce through porous and permeable soil media (Onyeobi and Akujieze 2014; Omorogieva et al. 2016; Talabi and Kayode 2019). Injection well within the depth

range of 0–40 m could easily facilitate the movement of such stormwater into shallow unconfined and semi-confined aquifer. The key objectives of the study are to assess the quality of groundwater in boreholes within and around the aquifer in environment prone to flooding, and IWs are used as a method of flood control, generate geospatial maps in relation to groundwater flow and carry out correlation analysis to determine the relationship between the concentration of parameters in the groundwater in BHs and IWs. The outcome of the study will give a detailed account, and evidence-based of the use of IWs as a method of flood control.

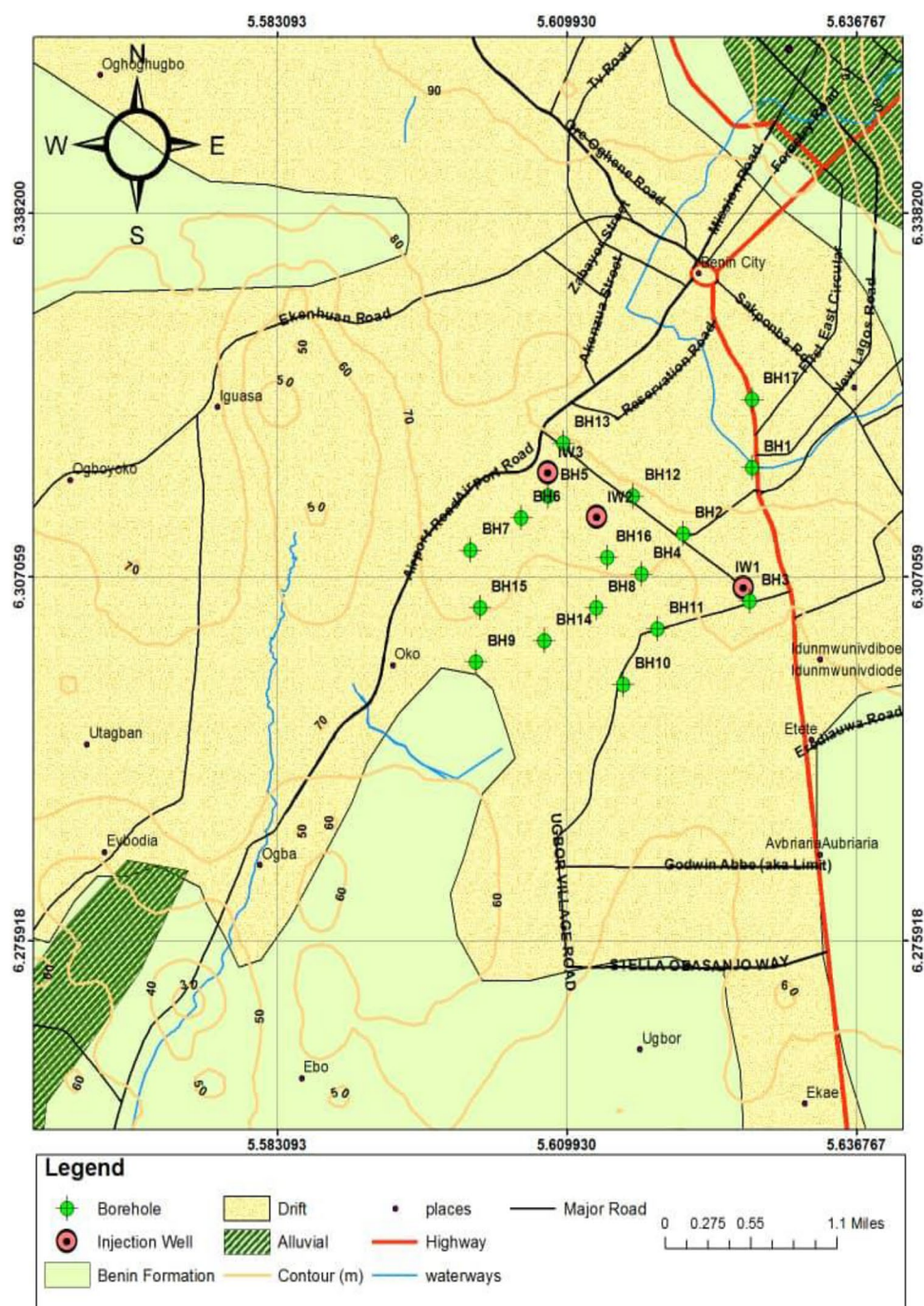
Materials and methods

Study location and its geology

The study focuses on the use of IWs within the Government Reserved Area (GRA) in Benin Metropolitan City (BMC), Edo State, Nigeria. By the application of Global Positioning System (GPS), the area falls within latitudes 6° 17' 59.72' ' N–6° 19' 29.47" N and longitudes 5° 35' 15.6" E–5° 37' 54.27" E. According to the National Population Commission (NPC 2006) and Wikipedia free encyclopedia (2020), BMC has an estimated population of 1,147,188 in 2006 and 1,495,800 at the last estimation in 2015, with a population density of 1200/km² (3200/sq mi) respectively. Climatically, the area is classified under Tropical Rainforest Belt of Nigeria characterized by heavy rainfall of about 1500 mm (60 inches) accompanying with thunderstorms and relatively high humidity of 60%, and a temperature of 27 °C, respectively (Omorogieva and Andre-Obayanju 2020).

Geologically, the area falls under Benin Formation (BF) which is overlain by tropical red soil (drift) and underlain by the Agbada Formation (AF). The Formation is characterized by high sand percentage (70–100%) and forms the top layer of the Niger Delta depositional sequence. The massive sands were deposited in a continental environment comprising the fluvial realms (braided and meandering systems) of the upper delta plain (Nwajide 2013; Ogieriakhi 2019). It is a continental deposit; various structural units are identifiable within the Formation, indicating the variability of the shallow water depositional medium. The thickness is about 2100 m, it is made up of Deltaic Coastal Plain (DCP) which is subdivided into upper coastal deltaic plain (freshwater) and lower coastal deltaic plain (brackish water), Akpoborie et al. (2015). Figure 1 represents the geologic and sample location map indicating the various rock strata and sampling points.

Fig. 1 Geologic and sample location map indicating rock strata and sampling points modified after Akujieze (2004). Note: *BH* borehole and *IWs* injection wells



Determination of groundwater flow direction

Prior to sample collection, groundwater flow direction map was determined by measuring the depth to water table also known as Static Water Level (SWL) in each of the boreholes (BH) around the selected IWs. Firstly, SWL was measured with the aid of a calibrated deep metre. The values obtained were subtracted from the Elevation measured above Sea Level (EASL) using Global Positioning System (GPS) during field study. The differences in the values of the SWL and

the EASL resulted in the Corrected Water Level (CWL) as presented in Table 1. The values of the CWL were used to generate a groundwater flow map using ArcGIS software as shown in Fig. 2.

BH and IW sampling technique

A total of 20 ($n=20$) samples of groundwater from BHs and IWs were systematically collected from the field with the aid of water pumping machine directly from the source in

Table 1 BH location, SWL and CWL measurements

Location	SWL (m)	EASL (m)	CWL (m)
BH1	47.00	82.00	35.00
BH2	42.00	77.08	35.10
BH3	49.00	68.64	19.60
BH4	41.00	70.44	29.40
BH5	43.00	79.82	36.80
BH6	45.00	78.98	34.00
BH7	42.00	75.69	33.70
BH8	46.00	65.12	19.10
BH9	47.00	68.02	21.00
BH10	45.00	72.27	27.30
BH11	44.00	67.47	23.50
BH12	48.00	84.33	36.30
BH13	46.00	79.32	33.30
BH14	41.00	66.96	26.00
BH15	44.00	67.77	23.80
BH16	43.00	72.27	29.30

a sterile rubber bottle of 75 Centiliter (cL), tightly covered and taped to minimize oxidation and escape of dissolved gases. The samples include sixteen (16) groundwater from BHs within the residential quarters of the study area, three (3) IWs within the vicinity of study as depicted in Fig. 1, and another one (1) groundwater from a BH sited in a pristine environment about 1.4 km from the study area bearing the same geological formation to serve as control (C). Two drops of Nitric Acid (HNO_3) were dropped in the cation sampling bottle to prevent metallic ions from adhering to the walls of the container and homogenize the water sample (Omorogieva 2014). The collection of water samples from IWs was to juxtapose the influence of flooding on the collected groundwater samples obtained from BHs in the study area. The samples were labelled appropriately, kept in a cooler and transported to the laboratory for analysis within 24 hours.

Laboratory analyses

Water samples were analysed for pH, turbidity, heavy metal (Pb, Ni, Cr, and Fe), Coliform, and *E. coli* species.

Hydrogen ion concentration (pH)

The pH value of the water samples was determined using the Hanna pH meter instrument Hi-1922 model after being standardized with buffers of pH 4.0 and pH 9.0, respectively. The results are represented in Fig. 3.

Determination of turbidity

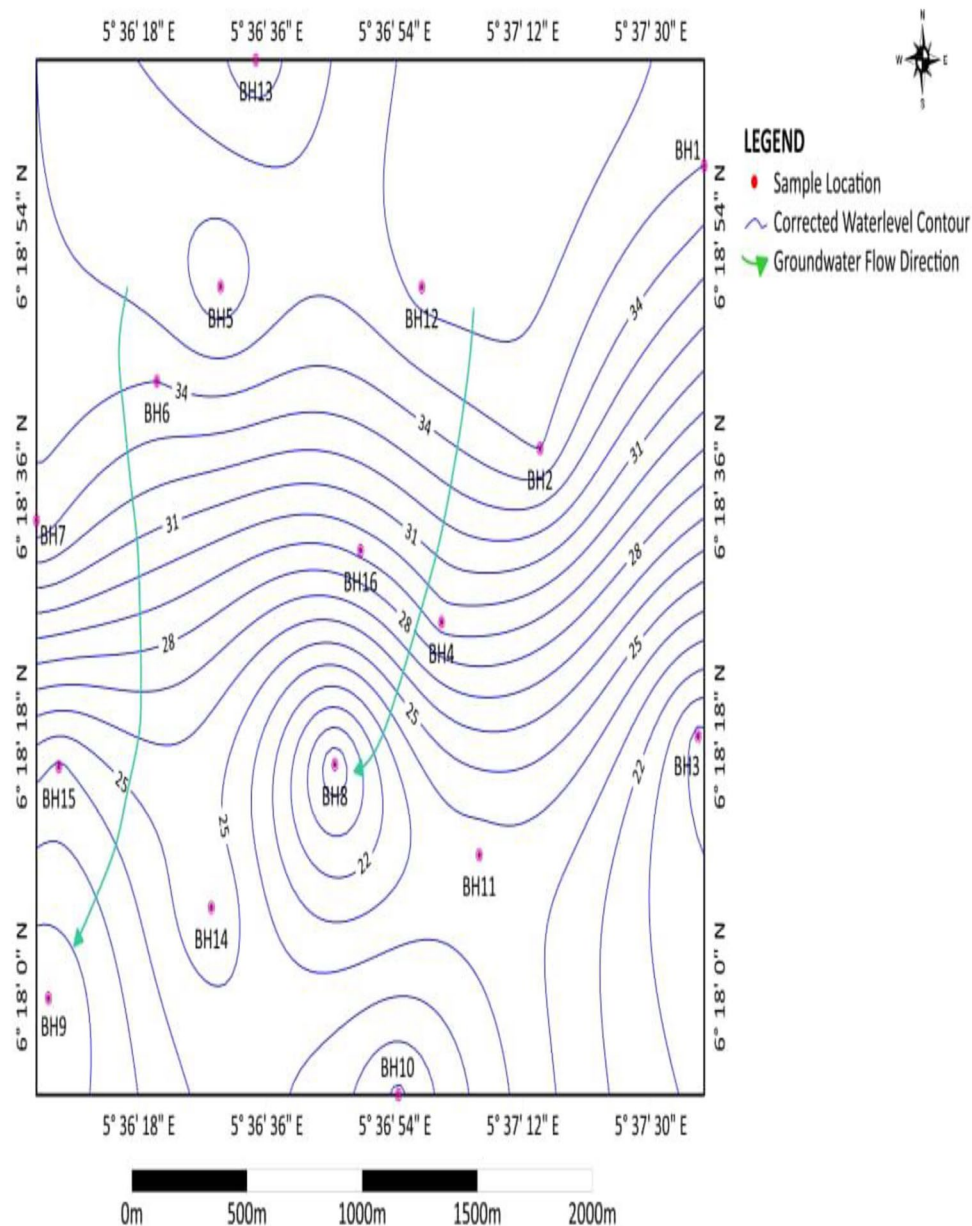
Turbidity was determined using the cell riser which was installed in the cell holder of model 2100A turbidimeter in one of the two highest ranges (100 or 1000 NTU). A clean sample cell of turbidimeter was filled with 25 mL of each sample and covered with a light shield, and turbidity of the various water samples was read in nephelometric turbidity units (NTU), the results are presented in Fig. 4.

Heavy metal analysis

Lead (Pb), Nickel (Ni), Chromium (Cr), and Iron (Fe) were determined after acid digestion with Atomic Absorption Spectrometer (AAS) modern 969 Unicam series with air acetylene following the steps outlined in Method 3005A (Method 3005A acid digestion of waters for total recoverable or dissolved metals for analysis by flaa or icp spectroscopy 1–5. <https://www.epa.gov/sites/production/files/2015-12/documents/3005a.pdf>) and APHA (2005) for acid digestion with slight modification. Two (2 mL) of conc. HNO_3 was measured in a 250 mL volumetric flask containing the water sample. Five (5 mL) of concentrated Hydrogen Chloride (HCl) was further added to the solution which was covered with foil paper and placed on a hot plate for a few minutes and heated to a temperature of about 80–85 °C. The samples were allowed to cool for a few minutes, before filtering into a 120 mL plastic bottle prior to Atomic Absorption Spectrometer (AAS) analysis. The results obtained in the experiment are presented in Figs. 5a, 6a, 7a, and 8a whereas, Figs. 5b, 6b, 7b, and 8b represents the geospatial maps produced to model the spread of the heavy metals.

Determination of coliform count BHs and IWs groundwater samples

Coliform levels were analysed using the Most Probable Number (MPN) method. Serial dilutions of 10^{-1} – 10^{-8} were prepared by serially diluting one (1) mL of the water sample. One-milliliter (1 mL) aliquots from each of the dilutions were inoculated into 5 mL of MacConkey Broth with inverted Durham tubes and incubated at 37 ± 05 °C for Total Coliform (TC) and 44 °C for Faecal Coliform (FC) for 18–24 h, respectively. Tubes showing colour change from purple to yellow and gas collected in the Durham tubes after 24 h were identified as positive for both total and faecal coliform. Counts per 100 mL were calculated from MPN Tables (WHO 1984; Anon 1992). The results recorded are presented in Fig. 9a.

Fig. 2 Groundwater flow map

Determination of *E. coli* specie in BHs and IWs groundwater samples

From each of the positive tubes identified in experiment 1 for *Coliform* count, a drop of the solution was transferred into a 5 mL test tube of tryptone water and incubated at 44 ± 05 °C for 24 h before adding a 5 mL Kovac's reagent. Tryptone water is best used for the detection of indole forming micro-organisms because of its high content of tryptophan, which makes it more reliable than peptone water (WHO 1984; Havelaar and During 2004; Merch 2020). All tubes showing a red ring colour development after gentle agitation denoted the presence of indole and recorded as

presumptive for thermotolerant coliform (*E. coli*). Counts per 100 mL were calculated using the MPN table (Fig. 10).

Production of geospatial maps

Geospatial maps for heavy metal and biological parameters measured in the study were developed using surfer 15 2D modelling software to model the direction of contaminants plume in relation to the IWs. The reason for this was to further probe whether the IWs influences the aquifer from which the BHs in the surrounding housing environments tap its groundwater. The results are presented in Figs. 5b, 6b, 7b, 8b, and 9b, respectively.

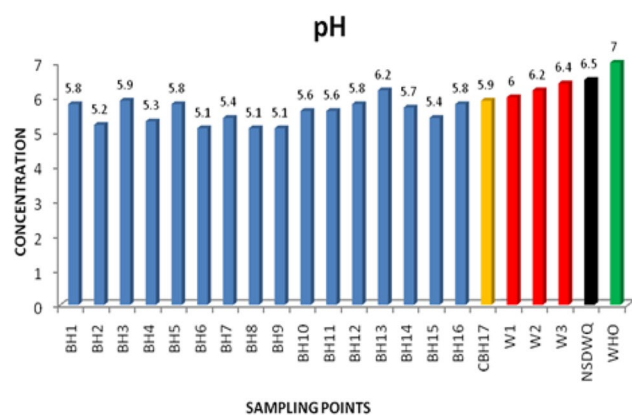


Fig. 3 pH values of collected samples in comparison to NSDWQ and WHO

Statistical treatment

Microsoft excel 2007 version was applied in the correlation analysis. The results of the correlation coefficient are represented in Table 2.

Results and discussions

The results recorded during field exercise, laboratory analyses of water samples and statistical analysis carried out shall be discussed in three subsections as follows;

Hydrogen potential (pH) and turbidity

The pH of water is one of the most essential parameters in assessing the quality of drinking water. Ideally, the pH of groundwater should be within the range of 6.0–8.5 while surface water ranged from 6.5 to 8.5 respectively (Xun

Fig. 4 Turbidity (ntu) values in comparison with NSDWQ and WHO

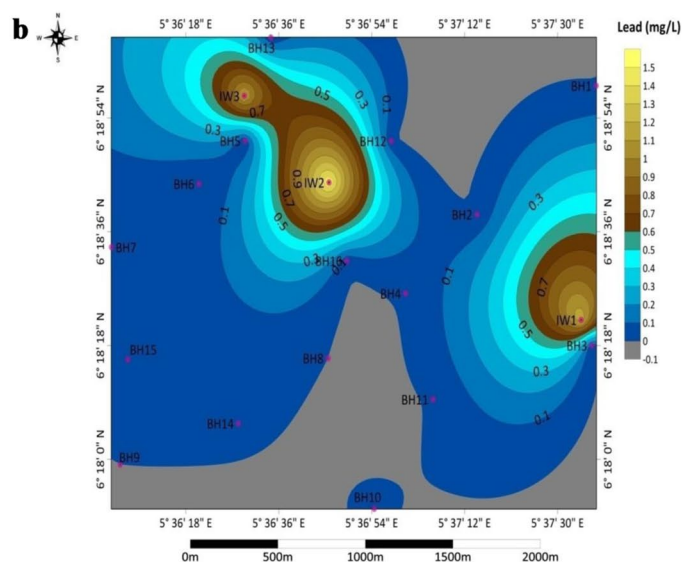
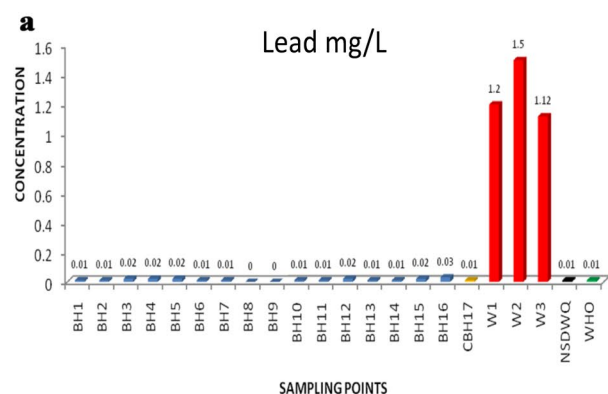
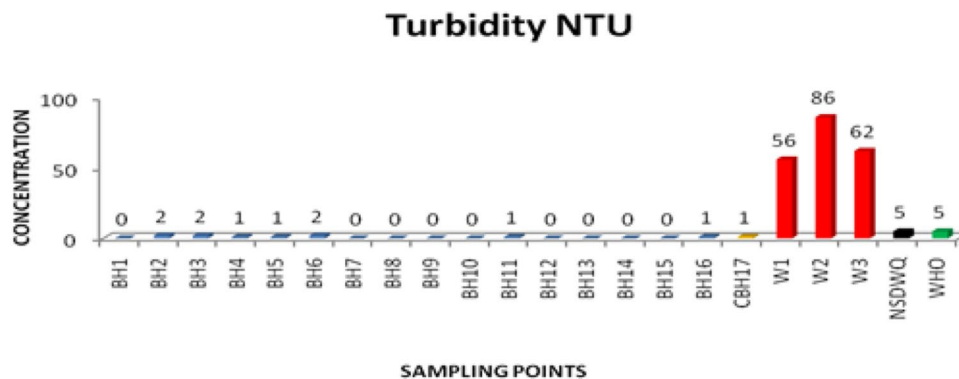


Fig. 5 **a** Concentration of Pb (mg/L) in BHs and IWs comparison to NSDWQ and WHO. **b** Geospatial map of Pb (mg/L) indicating the direction of plume

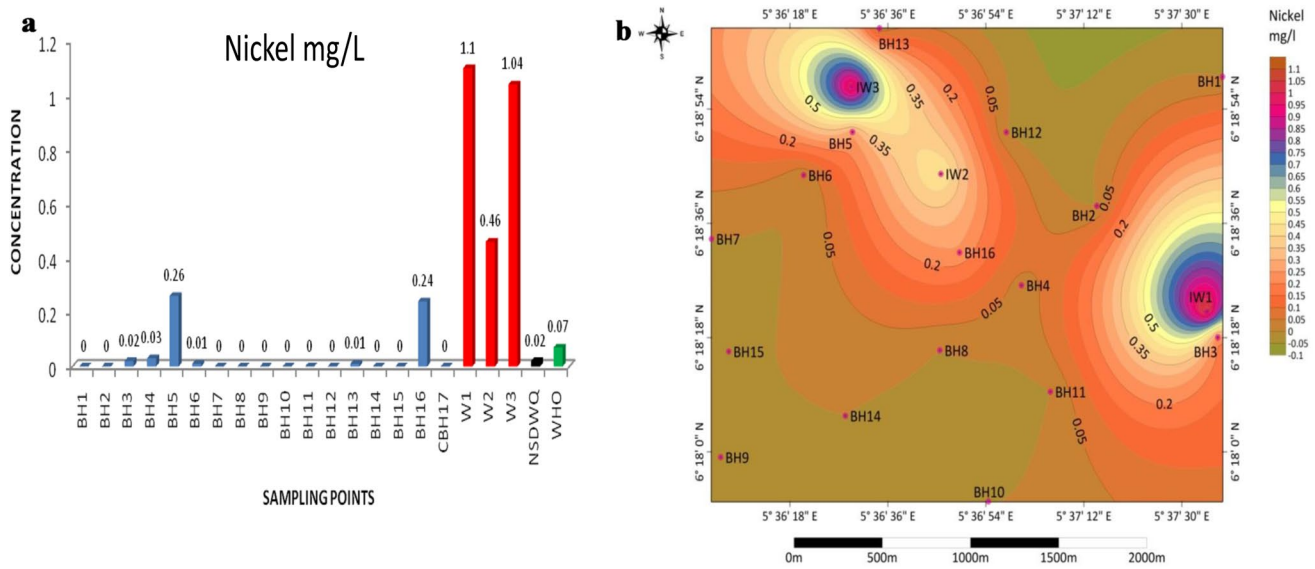


Fig. 6 **a** Concentration of Ni (mg/L) in BHs and IWs comparison to NSDWQ and WHO. **b** Geospatial map of Ni (mg/L) indicating the direction of plume

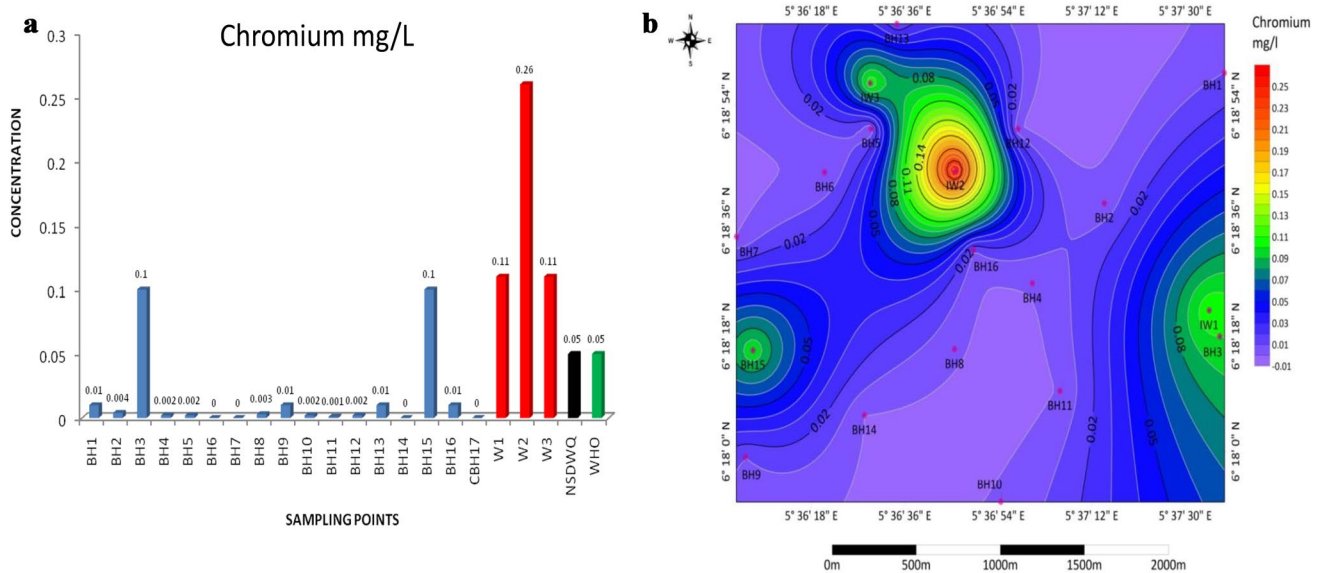


Fig. 7 **a** Concentration of Cr (mg/L) in BHs and IWs in comparison to NSDWQ and WHO. **b** Geospatial map of Cr (mg/L) indicating the direction of plume

et al. 2007). Characteristics of bedrock, aquifer configuration, lithology, and source of recharge are some of the main factors responsible for variation in water pH (Sciortino and Ravikumar 1999). In the current study, the pH values ranged from 5.1 to 6.2 with the highest pH value being 6.4 in injection well one (IW1) and the lowest pH values of 5.1 in BH6, BH8, and BH9. In comparison with national and international regulatory standards of National Drinking Water Quality Standard (SON 2015) and World Health

Organization (WHO 1984, 2011, 2012), it was observed that none of the borehole water met the standard range of 6.0–8.5 for potable groundwater (Fig. 3). The reason for the relatively low acidity and alkalinity as measured in the study could be attributed to the bedrock and unprofessional aquifer configuration in terms of casing, grouting, and blinding during well development. In the case of the IWs 1, 2, it was attributed to stormwater from rainfall which eventually infiltrates into the subsurface.

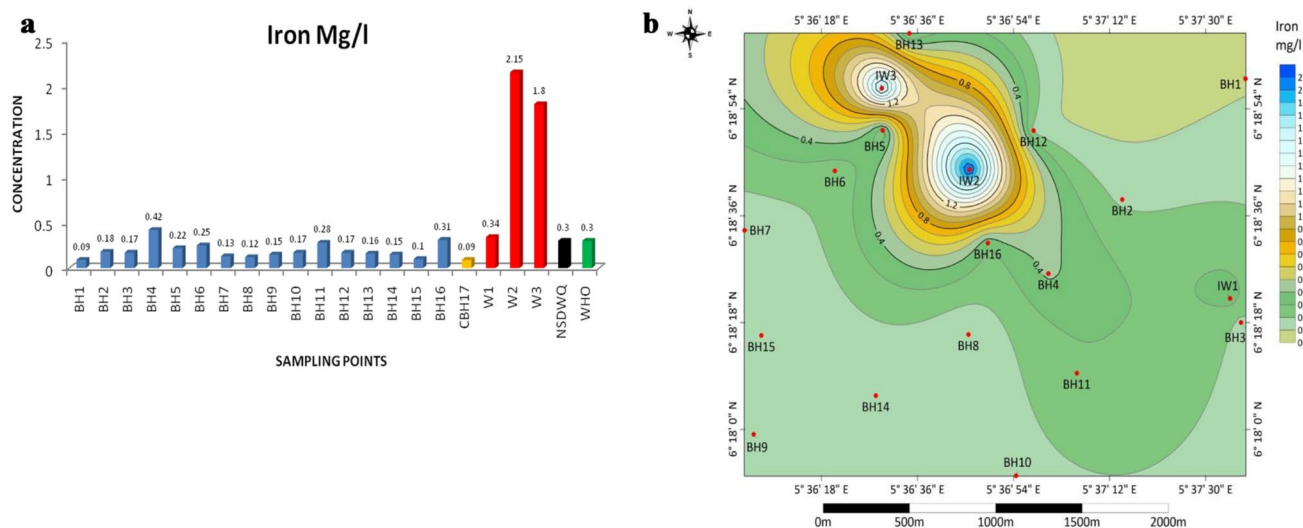


Fig. 8 **a** Conc. of Fe (mg/L) in BHs and IWs in comparison to NSDWQ and WHO. **b** Geospatial map of Fe (mg/L) indicating the direction of plume

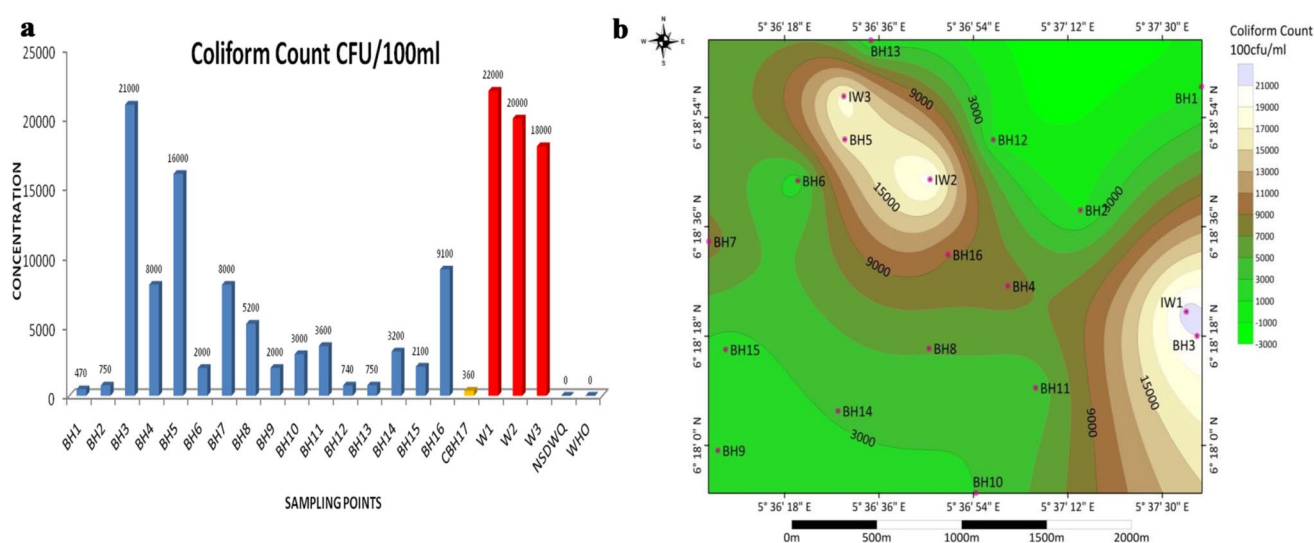


Fig. 9 **a** Coliform count (cfu/100 mL) in BHs and IWs in comparison to NSDWQ and WHO. **b** Geospatial map of Coliform count (cfu/100 mL)

Turbidity in water occurs as a result of suspended solids and colloidal particles which may be derived from dissolved substances from transporting medium, eroded soil, and dredging as in the case of surface water. It could also be as a result of growing micro-organisms domiciled in water. Water containing high turbidity can trap particles capable of encasing pathogens (Sciortino and Ravikumar 1999). Turbidity values recorded in the study area ranged between 0 and 86NTU with a mean value of 0.73 and 68NTU for BHs and IWs, respectively (Fig. 4). Although the values recorded in some of the BHs in the current study ranged from 1–2 NTU in BH2, BH3, BH4, BH5, BH6, and BH16 but were

below the limit of 5 NTU set by both NSDWQ and WHO for drinking water. Conversely, the mean value of 68NTU recorded in the IWs with the highest of 86 NTU in IW2 is alarming. Since groundwater moves through time, the risk of groundwater contamination in the area is inevitable (Toth 2020).

Heavy metal distribution

Figures 5a, 6a, 7a, and 8a represents the values in mg/L of the selected heavy metals in the study area, whereas Figs. 5b, 6b, 7b, and 8b showed the detailed geospatial maps used to

Fig. 10 *E. coli* (cfu/100 mL) in BHs and IWs in comparison to NSDWQ and WHO

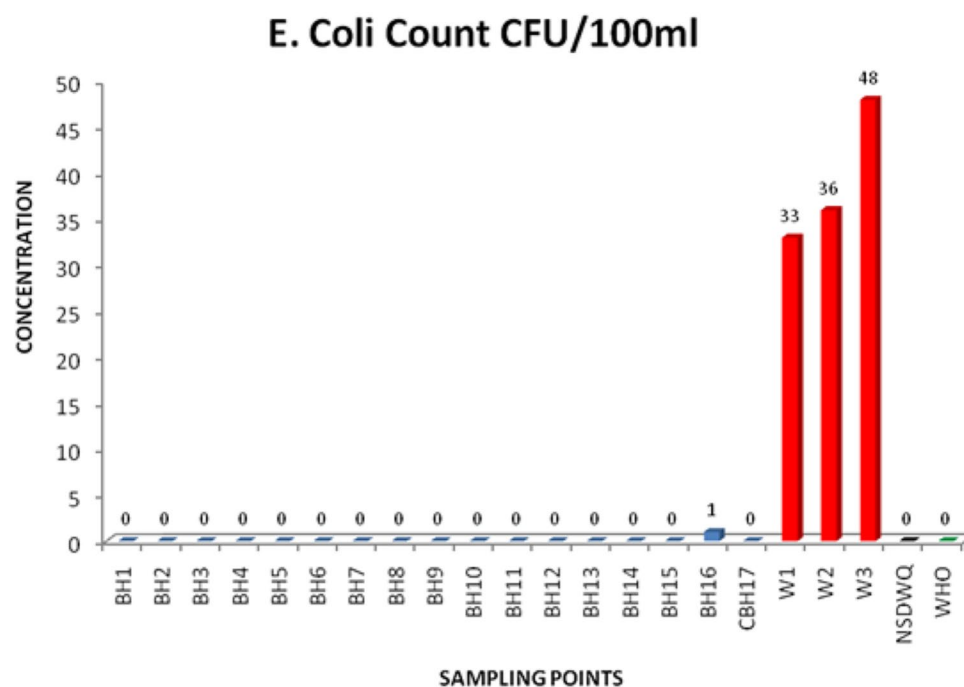


Table 2 Correlation of water parameter in BHs versus IWs

	pH BH	Turb	Pb BH	Fe BH	Cr BH	Ni BH	Coli. BH	<i>E. coli</i> BH
pH IW	1.000	0.382*	0.635**	0.278	0.471*	0.581**	0.298	0.589**
Turb. IW	0.382*	1.000	0.615**	0.754**	0.365	0.737**	0.540**	0.641**
Pb IW	0.635**	0.615**	1.000	0.667**	0.555**	0.780**	0.622**	0.733**
Fe IW	0.278	0.754**	0.667**	1.000	0.312	0.759**	0.628**	0.660**
Cr IW	0.471*	0.365	0.555**	0.312	1.000	0.541**	0.421*	0.639**
Ni IW	0.581**	0.737**	0.780**	0.759**	0.541**	1.000	0.739**	0.738**
Coli. IW	0.298	0.540**	0.622**	0.628**	0.421*	0.739**	1.000	0.607**
<i>E. Coli</i> IW	0.589**	0.641**	0.733**	0.660**	0.639**	0.738**	0.607**	1.000

Note : Figures in bold shows the strength of the relationship (correlation) between the variables measured; * indicates that the parameters are related whereas ** indicates that the parameters are strongly related, possibly from the same source

model the spread of Pb, Ni, Cr, and Fe from the position of the IWs.

The values recorded for Pb in groundwater samples within the study area ranged from 0 to 0.03 mg/L in BHs samples and 1.12–1.5 mg/L in the IWs. The mean and standard deviation recorded for Pb were 0.01 mg/L and 0.02 mg/L in the BHs and IWs respectively. The highest value of 1.5 mg/L Pb concentration was recorded in IW 2 while the lowest value of 0.001 mg/L was recorded in BH8 and BH9, respectively (Fig. 5a). Besides the IWs, BH3, BH4, BH5, BH12, BH15, and BH16 do not also meet the required limit of 0.01 mg/L (SON 2015; Toth et al. 2016; WHO 2020). Figure 5b represents the geospatial map used in modelling the spread of Pb plume. From the Figure, it was observed that the concentration of Pb decreases away from the IWs through the BHs south of the IWs indicating that the IWs are

a contributing factor to the occurrence of Pb in groundwater which were obtained from the BHs in the study area.

The values recorded for Ni in BH water samples within the study area ranged from 0 to 0.26 mg/L and 0.46 to 1.1 mg/L in the IWs. The highest values of 0.46, 1.04 mg/L, and 1.10 mg/L Ni were found in the IWs (Fig. 6a) with IW1 recording the highest value. In the BHs, the lowest values were found in BH1, BH2, BH7, BH8, BH9, and BH10. The values recorded in the IWs as well as BH5 and BH16 exceeded the 0.2 mg/L limit for national potable water but were below 0.07 limit set by WHO (2020). Figure 6b showed the spread of Ni in the boreholes assessed; the observation is similar to that of Pb.

Chromium in BH water samples in the study area indicates a range of 0.00–0.1 mg/L and 0.11–0.26 mg/L in the IWs. The highest value of 0.1 mg/L in BH was recorded in

BH3 and BH15 respectively (Fig. 7a). Conversely, a range of 0.11–0.26 mg/L was recorded in the IWs with the highest concentration of 0.26 mg/L in IW2 (Fig. 7a). The lowest concentration of 0.001 mg/L of Cr was found clustering around BH4, BH5, BH10, BH11, and BH12. The overall record showed that BH3, BH15, and the IWs were above the 0.05 mg/L required limit for potable water set by national and international agencies in charge of water quality monitoring. Figure 7b represents the concentration map used in modelling the contaminant. The increase in concentration above the limits set by regulatory agencies is attributed to contaminated percolating flood water transported from hinterland to the flooding site.

In the case of Fe, the values recorded ranged from 0.09 to 0.42 mg/L in the BHs while the range of the IWs was from 0.34 to 2.15 mg/L (Fig. 8a).

It was observed that BH4 and BH16 including the IWs do not meet the required limit of 0.3 mg/L for water quality assessment (Sciortino and Ravikumar 1999). Modelling the plume (Fig. 8b) revealed that Fe contaminant spread away from the IWs indicating a primary source.

Faecal coliform and *E. coli* counts

The results in this study indicate that the introduction of IWs in controlling floodwater in the area of study shows a direct link between the contaminations of groundwater by contaminated surface water carried by storm especially during the wet season. The *Coliform* Count recorded in this study ranged from 360 Coliform Forming Unit/100 mL (cfu/100 mL) in BH17 as control to 22,000 cfu/100 mL in IW1. Boreholes tagged BH3, BH5, BH16, BH4 and BH7 recorded the highest values of 21,000, 16,000, 9100 and 8000 cfu/100 mL (Fig. 9a). The lowest value of coliform was recorded in a residential borehole tagged BH1 with 470 cfu/100 mL. It is interesting to know that BH3 with the highest value of 21,000 cfu/100 mL was a few metres away from IW1 which recorded the highest value of 22,000 cfu/100 mL in the IWs. The BHs with the highest values cluster around the IWs and gradually reduce in values some distance away from the IWs in the direction of groundwater flow (Figs. 1 and 2). Conversely, BHs with lower values were recorded at some distance away in the reverse side of groundwater flow and concentration of floodwater which further support that the IWs are the medium through which the biological pollutants were introduced into the groundwater (Osaze et al. 2013; Pawari and Gawande 2015; Takal and Quay-Ballard 2018). Figure 9b represents the modelling of coliform spread. It indicates that the IWs are the epicenter of the biological contaminants. Further support was observed from the results obtained in *E. coli* count represented in Fig. 10. Besides, the IWs recorded 48 cfu/100 mL in IW3, 36 cfu/100 mL in IW2, and 33 cfu/100 mL in IW3; no *E.*

coli species presence was found in any of the BHs including the control point tagged BH17. The entire area of study had a concentration of coliform count above zero cfu/100 mL that exceeded both the National and International limit of NSDWQ and WHO respectively for potable water standard. The same was observed for *E. coli* in BH16 and the IWs respectively. The presence of *E. coli* and TC in groundwater is a strong evidence of sewage, a byproduct of animal and human faeces which indicates pathogenic organisms harmful to human health (Water Stewardship Information Series 2007; Minnesota Department of Health 2019).

Groundwater flow map generated for the area indicates that the groundwater in the area flows from north to south which is controlled by the piezometric surface (Toth 2016). The movement of groundwater in the area to a large extent influences the spread of the contaminants within and across the BHs in the areas (Fig. 2). This was evident in the spread of heavy metals, *Coliform* and *E. coli* counts as earlier explained with the geospatial maps generated.

Correlation in groundwater

Correlation at $P < 0.01$ two-tailed was performed to demonstrate the relationship between the parameters measured in groundwater obtained from BHs and IWs in the study area. The results obtained showed a correlation coefficient range of $R^2 = 0.278$ to 0.780 with Fe and pH having the least correlation of $R^2 = 0.278$ and Ni and Pb having the highest correlation of $R^2 = 0.780$. The poor correlation of Fe in BHs and IWs indicates that the presence of Fe in IWs is not as a result of the percolating flood water but as a result of geogenic factor, possibly the leaching of the overlying red soil rich in Fe and bedrock anomaly concentration. Conversely, the strong positive correlation between the heavy metals and the biological parameters is a strong indication that Pb, Ni, Cr, Coliform and *E. coli* Counts in the BHs water samples were influenced by the percolating flood water introduced into the groundwater system through the IWs. Turbidity in both BHs and IWs also shows a strong positive correlation coefficient range of $R^2 = 0.540$ with *Coliform Count* to 0.754 with Fe except with Cr where it has a value of $R^2 = 0.365$ indicating a different source. Lower pH influences the availability of some metals in water; this was demonstrated by the relatively low pH recorded in both BHs and IWs. By correlation, all parameters except Coli Count correlates positively both in BHs and IWs with pH (Robison et al. 2009; Zhou et al. 2015).

Conclusion

Groundwater is an essential commodity to global community due to its role in the day to day human activities, ecosystem functioning, agricultural advancement, industrial and societal development. Consequently, it's important to protect it against contamination for sustainable development. The study has examined the use of IWs as a control of flood; the method is gaining relevance globally as a result of its outcome. The study demonstrates the use of IWs though effective but poses significant risks on groundwater quality. On examination of the quality of groundwater in BMC in Nigeria, the results obtained showed that Pb, Ni, Cr, and the biological parameters of *Coliform* and *E. coli* Counts in the IWs as well as BHs within and adjacent positions were high in concentration and gradually dissipates in the direction of groundwater movement. This indicates that the use of IWs in containing flood water laden with toxicants has introduced contaminants into the groundwater system. If left unchecked, there could be water crises occasioned by groundwater pollution being experienced in some parts of the world. Since global population depend mainly on groundwater particularly for domestic use, and on the other hand, unchecked flooding activities can lead to serious environmental threat; it is therefore necessary that using IWs as a control measure of flood, and flooding-related activities, aquifer condition in the catchment area and groundwater movement should be known to avoid possible impacts of the IWs on groundwater. Based on this study, it is recommended that IWs of about 40 m deep can only be applied as a control measure of flooding activities in an environment where the depth to aquifer of at least 100 m in a confined nature is observed. Overall, water should be allowed to flow through its natural course irrespective of the need for land use while government, and all the stakeholders on the other hand should join hands in containing the menace posed by flooding by enacting laws geared towards sustainable environment and groundwater protection, and enforcing it to the latter.

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