



Quality of groundwater around mechanic workshops in Bauchi metropolis

Chioma Okeke¹, Baka Edward², Hannatu Akanang³

¹ Department of Chemistry, School of Science, Adamu Tafawa Balewa College of Education, Kangere Bauchi State, Nigeria

² Department of Chemistry, School of Pre-Degree and Allied Programs, Gombe State University, Gombe, Gombe State, Nigeria

³ Department of Chemistry, School of Science, Abubakar Tafawa Balewa University, Bauchi State, Nigeria

Abstract

The study investigated the quality of groundwater of nine well water samples collected in some areas around some mechanic workshops located within Fadamamada, Dutsen Warinje and Federal low Cost Road using standard methods, in order to assess the impact of auto-mechanic activities within these areas. Results obtained from analysis indicated that the mean values of all the studied parameters were below the limits set by Nigeria standards for drinking water quality ((NSDWQ) and the World Health Organisation (WHO) limits, except for EC and TDS of well 1 ($1126 \pm 1.10 \mu\text{S}/\text{cm}$, $562 \pm 1.00 \text{mg}/\text{l}$) and well 3 ($1118 \pm 1.30 \mu\text{S}/\text{cm}$, $593 \pm 1.20 \text{mg}/\text{l}$) in Federal low Cost Road, and colour of water in Well 1 (25 TCU) in Fadamamada, well (20 TCU) and well 3 (15 TCU) in Federal low Cost Road respectively. While the levels of Cu and Pb were below the standards limits used, Cr levels ($0.28 \pm 0.01 - 0.78 \pm 0.04 \text{ mg}/\text{kg}$), Cd ($0.01 - 0.02 \text{ mg}/\text{kg}$) and Mn (0.20 and $0.1 \text{ mg}/\text{l}$ respectively), except in wells 1, 2 and 3 in Dutsen Warinje were found to exceed their permissible limits. Based on these exceptional cases, the continuous monitoring of well water in the studied communities should be conducted so as to mitigate the risks that these mechanic workshops could pose on the quality of well water for domestic and other applications.

Keywords: Auto-mechanic facilities, groundwater, water quality, Bauchi, WHO

Introduction

Water is an essential resource for survival of all forms of life. It makes up about 50-95% of all plants and animals, and about 70% of human body. It is very important for all human activities including domestic, industrial, agriculture, manufacturing and transportation. Sources of water include ground and surface water. Groundwater is sourced through wells and boreholes by digging deep down impervious layers underground (Usman *et al.*, 2014; Gloria and Token, 2015) [28, 11]. Owing to increasing industrialization and exploding population, the demand for water supply have been increasing tremendously. There has been a deliberate shift toward reliance on groundwater for domestic and other needs, so groundwater has become a source of drinking water in many rural and urban communities around the world because of the relatively better quality, when compared to surface water.

These sources of water are often unpolluted due to restricted movement of pollutants in the soil profile (Murhekar, 2011) [18]. However, when water travels through the ground, it dissolves parts of the soil components and so may contain objectionable concentration of salts (Igwegmar *et al.*, 2013) [12]. The chemistry of this groundwater samples may be affected by poor well construction. Many hand dug wells do not have proper filter packs or are improperly grouted, so water seep down the casing from the surface or other ground water zones, thus adding to the contamination of ground water flowing through their intakes (John *et al.*, 2012). Residence times in groundwater are generally orders of magnitude longer than in surface waters. Once polluted, a groundwater body could remain so for decades, or even for hundreds of years, because the natural processes of through-flushing are so slow (Chilton, 1992 and 1996) [7]. It is therefore necessary to obtain a comprehensive picture of the

groundwater quality and the changes that occur in time, either naturally or anthropogenically.

Clean water meant for human daily consumption should be free of physical, chemical and biological impurities. Unfortunately, studies carried out in different parts of Nigeria have revealed that various sources of drinking water have been contaminated at varying scales by human activities including indiscriminate dumping of automobile and industrial wastes and presence of refuse dumps/landfills close to wells (Adewoyin *et al.*, 2013; Usman *et al.*, 2013; Popoola and Ayodele, 2016) [4, 25]. Many organic compounds and toxic chemicals, including heavy metals leach into potable water and could cause chronic illnesses and malfunction of the human body (Federal Government of Nigeria, 2000). In 1997, the World Health organization (WHO) reported that 40 % of deaths in developing nations occur due to infections from water related diseases. Diseases contacted through drinking water kill about 5 million children annually. Also an estimated 500 million cases of diarrhoea occur every year in children below 5 years in parts of Asia, Africa and Latin America (WHO, 2004a, 2004b, 2004c, 2011). More than 3.4 million people die each year from water sanitation and hygiene-related causes (Okeola, 2010; Igwegmar, *et al.*, 2013) [21, 12]. Since heavy metals are highly soluble in water, they can be easily transferred into living organisms and accumulate in the human system for a very long time. Though some metals (Zn, Co, Cu, Mn, Fe e.t.c) have nutritional importance, while metals like Cd, Pb, Ni, As and Hg are toxic to humans even at trace amounts. Metal toxicity in humans could damage the respiratory, skeletal, cardiovascular systems, kidneys, liver, heart and brain (Adebayo *et al.*, 2017; Kinuthia *et al.*, 2020) [3, 15].

Auto-workshops in Bauchi are continuously being reclaimed for residential purposes due to dramatic rise in the population. Most residents in these reclaimed polluted

workshops dig wells or sink boreholes in these areas due to water shortage while others farm on some portion of the land and use same well water for irrigation purpose. It is therefore imperative that water meant for drinking and other domestic purposes must not fall short of both local and international laid down standards to avoid serious health risk to consumers as a result of water borne diseases (Nwankwoala and Nwagbogwu, 2012) [19]. To determine water quality, several parameters are to be examined. These include conductivity, dissolved oxygen, pH, color of water, taste and odor, turbidity, total dissolved solids, chemical oxygen demand, biochemical oxygen demand, micro-organisms, fertilizers, dissolved metals and organics (WHO, 2011; Patil *et al.*, 2012) [24]. The purpose of the study therefore is to ascertain some of these dissolved metals, particularly heavy metals and some physico-chemical properties of well water in areas around mechanic workshops in Bauchi metropolis in order to generate baseline information for risk assessment of the water for both artisans and residents around these facilities.

Materials and Method

Study Area

The study was carried out in Fadamamada, Dutsen Warinje, and Federal low Cost Road, where some mechanic workshop clusters were identified around some residential areas. Three public hand-dug wells within each of these areas were assessed in order to determine the physico-chemical properties of the well water and their heavy metal concentrations.

Samples collection

The sample bottles and glassware were properly washed and soaked in 10% HNO₃ for 48 hours; and thereafter rinsed with distilled water before they were oven dried. A 2 litre plastic container was used to collect the water samples, which were adjusted to pH 2 and stored below 4°C in a refrigerator (Usman *et al.*, 2013).

Determination of physico-chemical properties and metal concentrations of water samples

The temperature of each sample was measured and recorded using a thermometer calibrated in degree Celsius. The pH, electrical conductivity, total dissolved solid, turbidity and

colour of the water samples were determined using the Potalab model WAG-WE10010. Some drops of Conc. HNO₃ was added to 200 cm³ of the water sample in a beaker at 120° C and then concentrated to about 100 cm³. The concentrations of the heavy metals were then determined using the Atomic Absorption Spectrophotometer.

Statistical analysis

With the aid of the SPSS 21, the descriptive statistics of the data obtained for the water samples were determined.

Results and Discussion

The results of the physico-chemical properties of the well water samples obtained are presented in Figures 1 – 12. The values of the parameters determined were compared to the Nigerian Standard for Drinking Water Quality (NSDWQ) and limits set by WHO.

The temperature (°C) of the well water samples obtained in the various automobile clusters were between 27.4 for well 3 in Fadamamada and 29.2 for well 2 in Federal Low cost (FLC) (Figure 1). The values for temperature obtained for the sampled wells were not significantly different. Values obtained here are within the range of 20 – 30°C set by the WHO for drinking water.

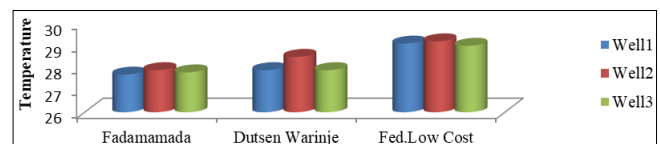


Fig 1: Temperature of well water samples from automobile workshop clusters

The temperature of drinking water is not considered as a major concern to consumers especially in terms of the quality. The values of temperature for wells in this study are consistent with values reported in Amoo *et al.* 2021 (29.6 – 31.7 °C)

The entire mean pH values of the well water samples in the various automobile clusters studies were lower than 7 (Figure 2). The well water samples are weakly acidic, though some of their values were well within the WHO and NSDWQ recommended range of 6.5 – 8.5.

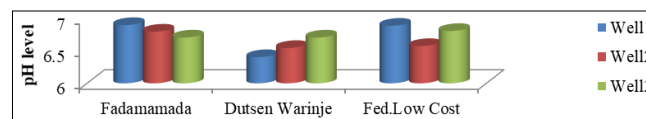


Fig 2: pH level of well water samples from automobile workshop clusters

The low pH levels (<6.5) recorded in this study could be an indication that contaminants such as metals ions may be present in the water samples. It could also mean deteriorating water quality. Very acidic water can be detrimental to human health and may lead to nutritional imbalance (Olalekan *et al.* 2018) [22]. Krishna *et al.*, (2019) [16] and Jasna *et al.* (2022) [13] reported pH values of 6.40 – 8.1 and 6.87 – 7.07 respectively for underground water. Amoo *et al.* (2021) also recorded pH values of 6.43 – 7.12 in hand dug wells in Gaya town in Nigeria.

The mean levels of EC in the well water samples were not significantly different in the study clusters, except for well 1 and 3 in Federal Low cost. Though the water samples in the

study sites showed EC values below the WHO and NSDWQ permissible limits of 1000µS/cm, values obtain for well 1 and 3 in Federal Low cost were substantially higher than the limits. The high EC in the well around the automobile clusters in this area may be attributed to high dissolved inorganic minerals in the mechanic workshop. EC values obtained in this study are consistent with the 650µS/cm and 320mg/l in Ahmed and Eyaife (2014) [5], 423 – 1197 µS/cm in Devi and Premkumar (2012) [8] and 207µS/cm to 657 µS/cm in Amoo *et al.*, (2021), but are higher than the (192.35 – 255.33µS/cm) for well water samples collected in mechanic workshop in Ibadan (Adewoyin *et al.*, 2013) [4]

and the 133 – 187µs/cm obtained for wells and bore-hole water in Abugu *et al.* (2022) [2]

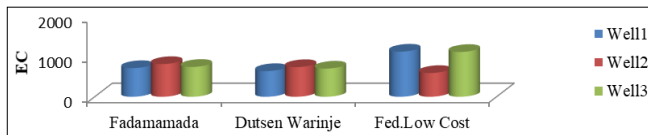


Fig 3: EC levels of well water samples from automobile workshop clusters

The mean values of the TDS measured in all the sampled well waters ranged from 295 to 593mg/L. Increased levels of TDS have been attributed to weathering of rocks and soil beneath the ground; and dissolved organic matter, an indication that water is polluted (Rao *et al.*, 2012). The values of TDS obtained in this study were below the limits (500mg/l) for drinking water set by NSDWQ, except in Federal Low cost (Well 1 and 3).

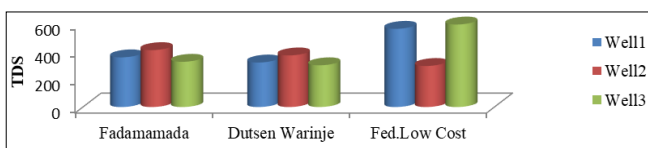


Fig 4: TDS level of well water samples from automobile workshop clusters

The values of TDS here are consistent with TDS values of 280–1312 mg/L recorded in Li *et al.*, (2022) [17], lower than the 1846 mg/l reported in Kerketta *et al.*, (2013) [14] but higher than of 145 – 245 mg/l reported in Pandey and Tiwari (2009) [23] and 132-184µs/cm in Abugu *et al.*, (2021). High TDS in groundwater may not pose any danger to healthy persons but could constitute a serious health risk on people with kidney and heart disease (Li *et al.* 2022) [17]. The turbidity values of the water samples were found to be between of 0.396 and 2.50 NTU in the study sites. Only in well 3 in Fadamamada was the turbidity level significantly higher than the other wells, while in Dutse Warinje, well 2 and 3 were significantly lower than others. The values obtained in all the sites were below the WHO and NIS permissible limit (5.0 NTU) for portable water. The level of turbidity of water indicates the presence of suspended particles. So the higher the amount of suspended particles in water, the greater the turbidity level of the water.

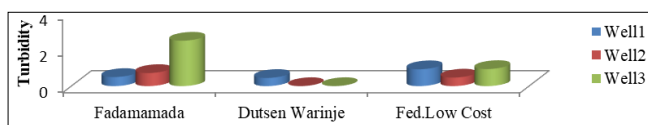


Fig 5: Level of turbidity of well water samples from automobile workshop clusters

The turbidity levels in the present study is consistent with those recorded by Tiimub *et al.*, (2012) [27] (0.59 –23.3NTU) in underground water analysis and in Amoo *et al.*, (2021) (0 – 4.85NTU) in hand dug wells. The values here are lower than the range of turbidity values recorded for wells (30 – 71 NTU) and boreholes (23 – 34 NTU) by Abdulkadir *et al.* (2017) [1]; and 23 NTU reported in Olalekan *et al.*, (2018) [22]. The presence of these finely divided solids particles which are not filterable by routine methods are a major health concern because they shield disease causing

organisms in the water from disinfectant (Ahmed and Eyaife, 2014) [5].

The colour of well water in the various mechanic clusters varied per site. Well 1, well 2, well 1 and 3 of Fadamamada and Federal Low cost respectively were significantly different compared to the other wells. The mean values for well water color obtained in the study were below the limits recommended by both NIS and WHO (15TCU), except for Well 1, well 2 and well 1 of Fadamamada (25 TCU), Dass road (20 TCU) and Federal Low cost (20 TCU) respectively. Popoola and Ayodele (2016) [25] reported 5TCU for well water in automobile repair workshop in selected areas in Ado – Ekiti. Color of water sometimes indicates the presence of suspended matter. The color obtained for the sampled wells in this study may be justified by the low level of turbidity of the samples in the sites. The exceptionally high values obtained for color in three of the wells may be due to the presence of colloidal Mn or Fe in water, which impact the color of water naturally (Ahmed and Eyaife 2014) [5].

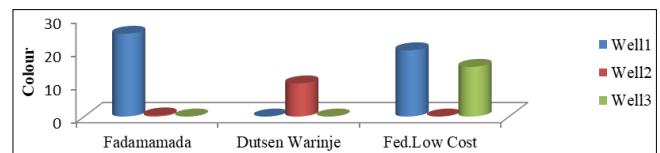


Fig 6: Colour of well water samples from automobile workshop clusters

Concentration of Metals in the Well Water Samples in Study Sites

Cr levels in the well water samples were observed to exceed the standards set by NIS and WHO standards (0.05 mg/L). Cr concentrations varied significantly in the study wells (Figure 7). The values measured were 0.28±0.01 – 0.78±0.04 mg/kg. Values reported in this work are higher than the Cr level of 0.001mg/l in Olalekan *et al.*, (2018) [22] but lower than the 29.0 and 5.0mg/l for Cr in Krishina (2019). The high level of Cr in this study may be attributed to its high solubility in water and thus its ability to contaminate well water through soil colloids.

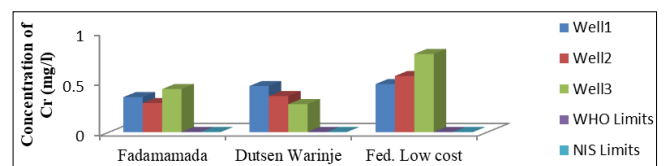


Fig 7: Concentration of Cr in the Well Water Samples in Study Sites

Cr especially Cr (VI) is hazardous and has been designated an “A” level carcinogen. Cr is an important element in steel, which is used in the manufacturing of various metallic parts of cars. When these metals deteriorate, Cr finds itself into underground waters through seeping. Chromium is also used in pigments, preservatives and paints (Usman *et al.*, 2013; Bikash *et al.*, 2021). Cr is essential in humans, as it regulates the blood sugar level and aid in body weight loss. Excessive exposure to Cr has been reported to cause skin irritation, impairment of the liver, kidney, pulmonary function and cancer. Chromate compounds can destroy DNA in cells (Njar, 2012; Kinuthia *et al.*, 2020) [1,15].

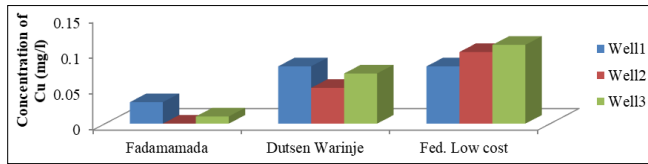


Fig 8: Concentration of Cu in the Well Water Samples in Study Sites

The level of Cu in the well water samples in Figure 8 ranged from 0.01 to 0.11 mg/kg. Cu was not detected in Well 2 in Fadamamada. The concentrations of Cu measured in the well samples were below the NIS and WHO standards (1.0mg/l and 2.0mg/l respectively). The value of Cu in this study is consistent with the less than 0.05mg/l in Mawari *et al.*, (2022) and the 0.011mg/kg in Poopola and Ayodele (2016) [25] but lower than the 0.001mg/l in Olalekan *et al* 2018 [22]. Higher values for Cu (4 and 17µg/L) were reported in Krishina (2019). Though Copper is essential in maintaining human health, chronic exposure through ingestion of contaminant drinking could lead to anaemia, liver and kidney damage (Esan *et al.*, 2015; Olalekan *et al.*, 2018) [9, 22]. Lenntech (2009) noted that a link exists between decline of intelligence in young adolescents and long term exposure to copper.

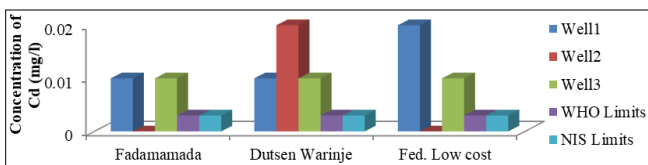


Fig 9: Concentration of Cd in the Well Water Samples in Study Sites

The concentrations of Cd in the water sampled were higher than NIS/WHO recommended values (0.003mg/l), except in Well 3 and Wells 2 of Fadamamada and Fed. Low Cost respectively (Figure 9). The levels of Cd in the various study wells samples were between 0.01 – 0.02mg/kg but are not significantly different from each other. The values are higher than the 0.001mg/l in Olalekan *et al.* (2018) [22], 0.002mg/l in Li *et al* (2022) [17] and 0.46 ± 0.06 to 0.59 ± 0.05mg/l in Ganiyu *et al.*, (2021) but lower than the 0.4 and 2.0µg/L in Krishina (2019). Cd has no known biological benefits but is highly toxic and carcinogenic. Studies have shown that renal failure, liver and kidney damage, hair loss, chronic anaemia and retarded growth are associated with Cd contamination (USEPA 1994; Esan *et al.*, 2015; Olalekan *et al.*, 2016) [9].

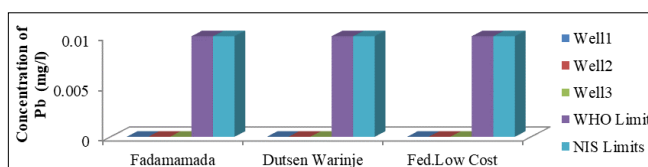


Fig 10: Concentration of Pb in the Well Water Samples in Study Sites

Figure 10 shows that the levels of Pb in the water samples were below the detection limit, showing the wells are not contaminated by Pb. The result obtained here are consistent with the 0.00mg/l in Esan *et al.*, (2015) [9] but lower than the values of 0.011 mg/l in Li *et al* (2022) [17], 0.01 – 0.84mg/l

reported in Ganiyu *et al.*, (2021), 0.001mg/l in Olalekan *et al.* (2018) [22]; and 3 and 82 µg/l reported in Krishina (2019) for well water samples.

While Popoola and Ayodele (2016) [25] reported Pb values of 0.001 mg/l to 0.004 mg/l for well water in automobile repair workshop in selected areas in Ado – Ekiti, Adewoyin *et al.*, (2013) [4] recorded Pb values as high as 6.59±5.71 to 21.35±4.91mg/l in well water samples in auto-mechanic workshops in Ibadan. Though Pb was not detected in the well sample in this study, high values of lead in water samples has been attributed to the use of Pb in gasoline, from car batteries and paints (Adewoyin *et al.* 2013) [4].

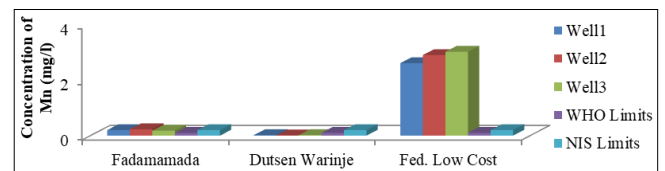


Fig 11: Concentration of Mn in the Well Water Samples in Study Sites

Mn concentrations in the water samples exceeded limits set by NIS and WHO (0.20 and 0.1mg/l respectively), except in wells 1, 2 and 3in Dutsen Warinje. The values of Mn determined ranged from 0.01 – 3.02 mg/l. Mn concentration in the study wells in this work are consistent with the Mn values of 0.60 ± 0.14 – 0.77 ± 0.06mg/l reported in Ganiyu *et al.*, (2021), 0.023 mg/l in Li *et al.*, (2022) [17] and 0.02mg/l in wells situated in an oil and gas producing area in River state in Olalekan (2018) [22]. High levels of Mn in groundwater will generate an unpleasant taste and odour in water, stain cloths and metal parts; and precipitate in foods when used for cooking. Mn ingestion has been reported to cause nervous system disorders; respiratory and digestion issues (Musa *et al.*, 2013; WHO, 2017; Ghosh *et al.*, 2020).

Conclusion

This analysis of the groundwater quality around mechanic workshops in Bauchi metropolis indicated that well water in some of the study sites have been impacted by the activities of artisans in these workshops. The concentrations of Cr, Cd and Mn in wells where they were detected were remarkably high. The well water in these areas therefore have been rendered unsuitable for drinking and other domestic purposes. The periodical assessment of physico-chemical analysis of the well water in samples in these areas and similar areas accommodating auto-mechanic workshops should be carried out; as this would be helpful in fully assessing the risk posed by these workshops on the quality of well water in our environment.

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