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Physicochemical parameters and selected heavy metals assessment of drinking water at the students' residences of the Nigerian Premier University

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Heavy metals contamination of drinking water is an important health risk factor due to the attendant toxic effect linked to it. We therefore assessed the quality of borehole, tap and well water samples in each of the seven students' residential areas of University of Ibadan. Physicochemical parameters of the water samples including pH, turbidity, total suspended solids (TSS), total dissolved solids (TDS), as well as concentration of iron (Fe), lead (Pb) and cadmium (Cd) were determined. The pH ranged from 4.2 to 5.5, 2.3 to 6.1 and 4.6 to 5.9; while turbidity ranged from 1.74 to 8.7, 1.7 to 13.0 and 1.69 to 4.35 NTU for well, tap and borehole water respectively. On the other hand, TDS was in the order of 1.83 to 620, 131 to 590 and 129 to 409 mg/L; and TSS value ranged between 17.9 to 68.8, 21 to 24 and 10.4 to 38.1 mg/L, respectively for well, tap and borehole water samples. Mean Cd concentration for the water samples in all of the residences were found to be within the USEPA maximum concentration limit (MCL) of 0.005 mg/L. However, Fe level exceeded USEPA MCL in some residences while Pb was higher than the permissive level in all of the study areas, up to 6.9 times the MCL for tap water in one of the students' residences. Findings from this study show that water sources in the residential areas of students of University of Ibadan were contaminated and may constitute health risk long term.

Key words: Drinking-water; physicochemical parameters; heavy metals; tap-water; health risk factor.

INTRODUCTION

Access to safe drinking water has improved substantially over the last decade in many parts of the world (Mintz et al., 2001). Developing countries of the world however face a lot of challenges in the area of water pollution. Heavy metals are becoming widespread as environmental pollutants as a result of intensifying human activities. The presence of heavy metals in fresh water has been described as the most important environmental threat of the future (Virha et al., 2011). Pollution of water bodies may occur by way of agricultural (Shrivastava et al., 2001), anthropogenic (Sambyal et al., 2004, Wepener et al., 2001, Martin-Gonzalez et al., 2006) and industrial (Kambole, 2002; Jindal and Kaur, 2000) wastes.

There is differential toxicity of these metals and several

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Abbreviations: TSS, Total suspended solids; **TDS,** total dissolved solids; **MCL,** maximum concentration limit; **NTU,** nephelometric turbidity units.

studies have been used to predict their mobility, bioavailability and the health risk from contaminated and wastewater (Chaudri et al., 2007; Khan et al., 2008; Wu and Cao, 2010; Fu et al., 2009; Li et al., 2009, Zabin et al., 2008).Their persistence, biomagnifications and accumulation in the food chain mean that they pose a significant threat to public health. Severe effects that have been associated with their ingestion include reduced growth and development, organ and nervous system damage, cancer and, in extreme cases, death (Rajendran et al., 2003; Johnson and Hallberg, 2005).

Physicochemical parameters provide a useful index in the determination of water quality. Some of the physicochemical parameters that have been used in the measurement of quality of water include pH, total suspended solids, dissolved metals and salts, taste and odour, turbidity and presence of microorganisms like coliform bacteria and so on (Virha et al., 2011; Hagan et al., 2011).

The aim of this study was to assess the quality of water in the students' residential areas of University of Ibadan, Nigeria in order to find out if they may constitute health risk. We estimated the level of heavy metal pollutants [iron (Fe), lead (Pb) and cadmium (Cd)] in the pipe borne water (tap water), hand dug well and boreholes in the students' residences, both within and off campus. In addition, we measured their pH, total suspended solids (TSS), total dissolved solids (TDS) and turbidity. These water bodies serve as sources of water for domestic cooking, laundry and drinking for the residents and neighbourhood.

MATERIALS AND METHODS

The study areas are the University of Ibadan student halls of residences namely Independence Hall (IH), Mellanby Hall (MH), Obafemi Awolowo Hall (OAH), Queen Elizabeth Hall (QEH) and Tafawa Balewa Hall (TBH) and selected estates at Agbowo Adegbite Street (AA), Agbowo Ile-Eja (AIE) and Abadina (AB) where a large proportion of the University of Ibadan students reside. Water samples were drawn from hand-dug wells, boreholes and tap water in the study areas indicated on the map (Figure 1A and B).

From each sampling point, triplicate water samples were collected and kept in sterilised-bottles which have been cleaned by rinsing with 5% nitric acid followed by distilled water and then with the specific sample water to prevent contamination from other sources. The water samples were taken to laboratory for immediate analyses; otherwise the samples are stored in sealed bottles at 4°C. Standard methods were used to determine pH, turbidity, total suspended substances and total dissolved solids (WHO, 1996). Determination of pH was by pH meter and turbidity by turbidimeter. For the metal analysis, water samples were digested with 5 ml of diacid mixture (HNO_3: $HClO_4$ :: 9:4) on a hot plate and filtered through Whatman no. 42 filter paper, and the filtrate made up volume to 50 ml using double distilled water. Levels of iron, lead and cadmium, were determined by atomic absorption spectrometry (AAS). Heavy metals level and physicochemical data were expressed as mean ± SD for three determinations.

RESULTS

Comparison of physicochemical parameters of source water of the University of Ibadan student residences

TDS, TSS and pH of the water samples were determined. Results of the analyses of these parameters in the water from boreholes located at Agbowo Adegbite Street (AA), Agbowo Ile-Eja (AIE), Independence Hall (IH), Mellanby Hall (MH), Obafemi Awolowo Hall (OAH), Queen Elizabeth Hall (QEH) and Tafawa Balewa Hall (TBH) are shown in Figure 2A. Mean turbidity values for the borehole water from MH, OAH and QEH (3.5, 4.35 and 3.91 NTU, respectively) are relatively high when compared with the values from other residences. On the other hand, the mean TDS values are similar for borehole water in all resident areas except for AIE. The mean TSS value of borehole water from AA nearly doubles (38.1 mg/L) that of borehole water from each of the other residences in this study where the TSS values are in the ranges (10.4 to 19.5 mg/L). The mean pH values of the borehole water from all residences are very similar.

The observed mean pH values for tap water and well water (Figure 2B and 2C) follow similar patterns as with the borehole water samples in all the residences except for AIE and QEH tap water where the pH values are very low; that is, 2.3 and 3.9, respectively (Figure 2B). The well water samples generally have pH values that are low compared with tap water and borehole water. The turbidity values of the tap water from all the resident areas are generally low and comparable with those of the borehole except for AIE where the turbidity was 13.0 NTU (Figure 2B). The turbidity, TDS and TSS values of well water are generally higher than the value observed for tap water (Figure 2B vs. Figure 2C). Among the students' residences within the campus of University of Ibadan, well water at the OAH had the highest level of TDS while the highest level of turbidity and TSS were associated with the well water samples from MH. Well water samples from Abadina (AB) and IH had very similar physicochemical parameters.

Level of heavy metals (iron, cadmium and lead) in the water samples

The concentration of heavy metals, Fe, Cd and Pb were determined from the sample water drawn from borehole, tap and wells located in the study areas. The concentration of Fe (mg/L) was exceptionally high for borehole water samples from AA and TBH (Figure 3A), whereas in QEH it was the value of Pb from borehole water that was the highest among all the samples from the residences. Mean Cd concentration obtained in the borehole water sample from AA, AIE, IH, MH, OAH, QEH

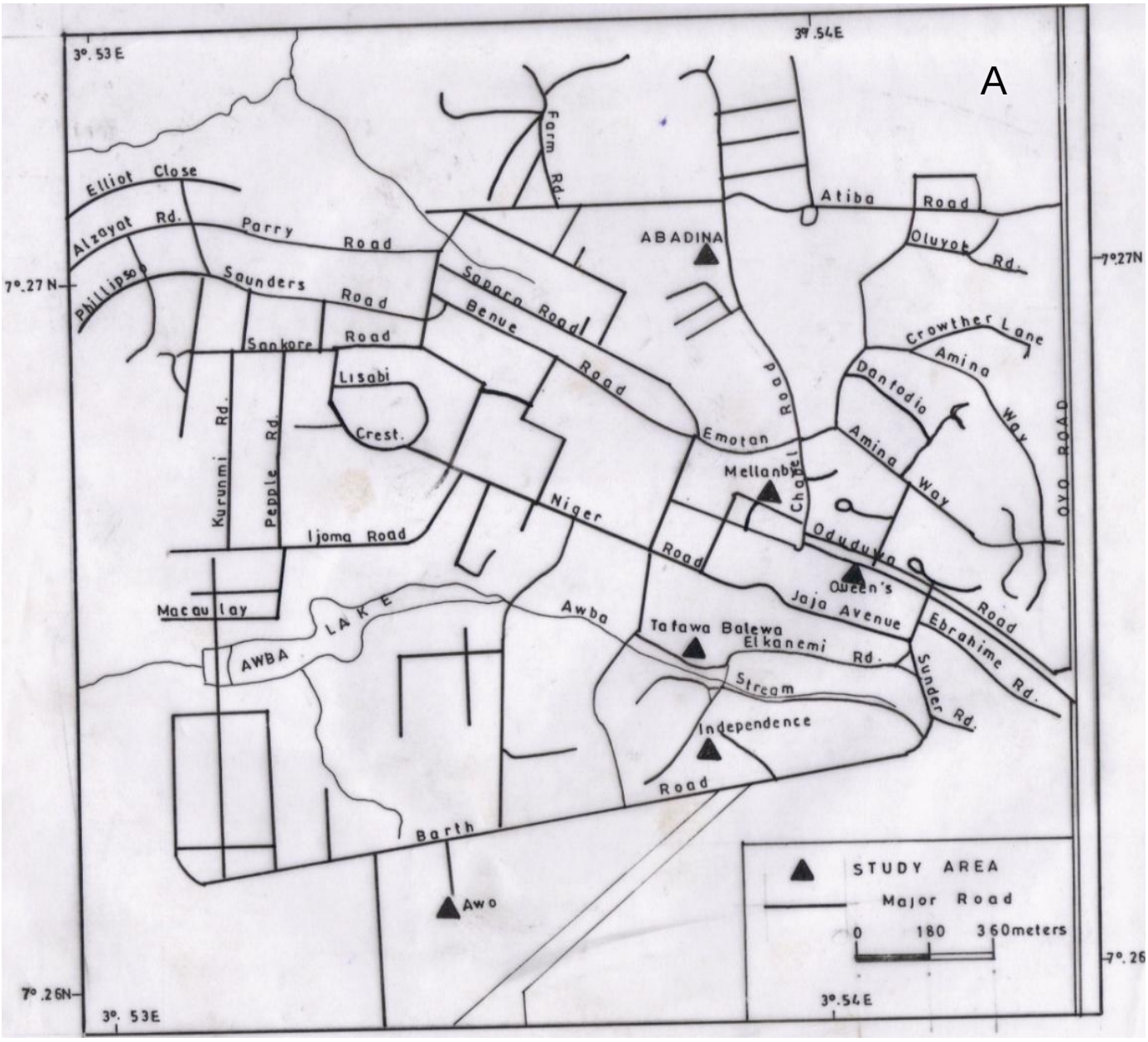

Figure 1A. Maps of University of Ibadan showing the study areas (▲ of the students' residences on the campus.

and TBH were in the range (0.001 to 0.003) mg/L (Figure 3A).

Analysis of iron concentration (mg/L) in tap water samples (Figure 3B) revealed between low values for AB (0.077) and TBH (0.037); medium for MH (0.162) and high for IH (0.472), AIE (0.318), OAH (0.348) and QEH (0.585). On the other hand, the mean Cd concentration in tap water was 0.002 mg/L for all residences except AB, where the value was 0.003 mg/L (Figure 3B). For lead, the range was between 0.044 to 0.054 mg/L except TBH, where mean value was 0.023 mg/L. Analyses of iron in the well water samples showed similar values in all the residences studied (0.117 to 0.347) mg/L (Figure 3C). Similarly, mean Cd concentration is 0.002 to 0.003 mg/L in all the water samples except AIE (0.004 mg/L) and MH (0.001 mg/L).

On the other hand, determination of Pb concentration in the well water samples (Figure 3C) gave values in the range (0.018-0.036 mg/L) except for AIE and QEH where values are above this range (that is, 0.07 and 0.104 mg/L,

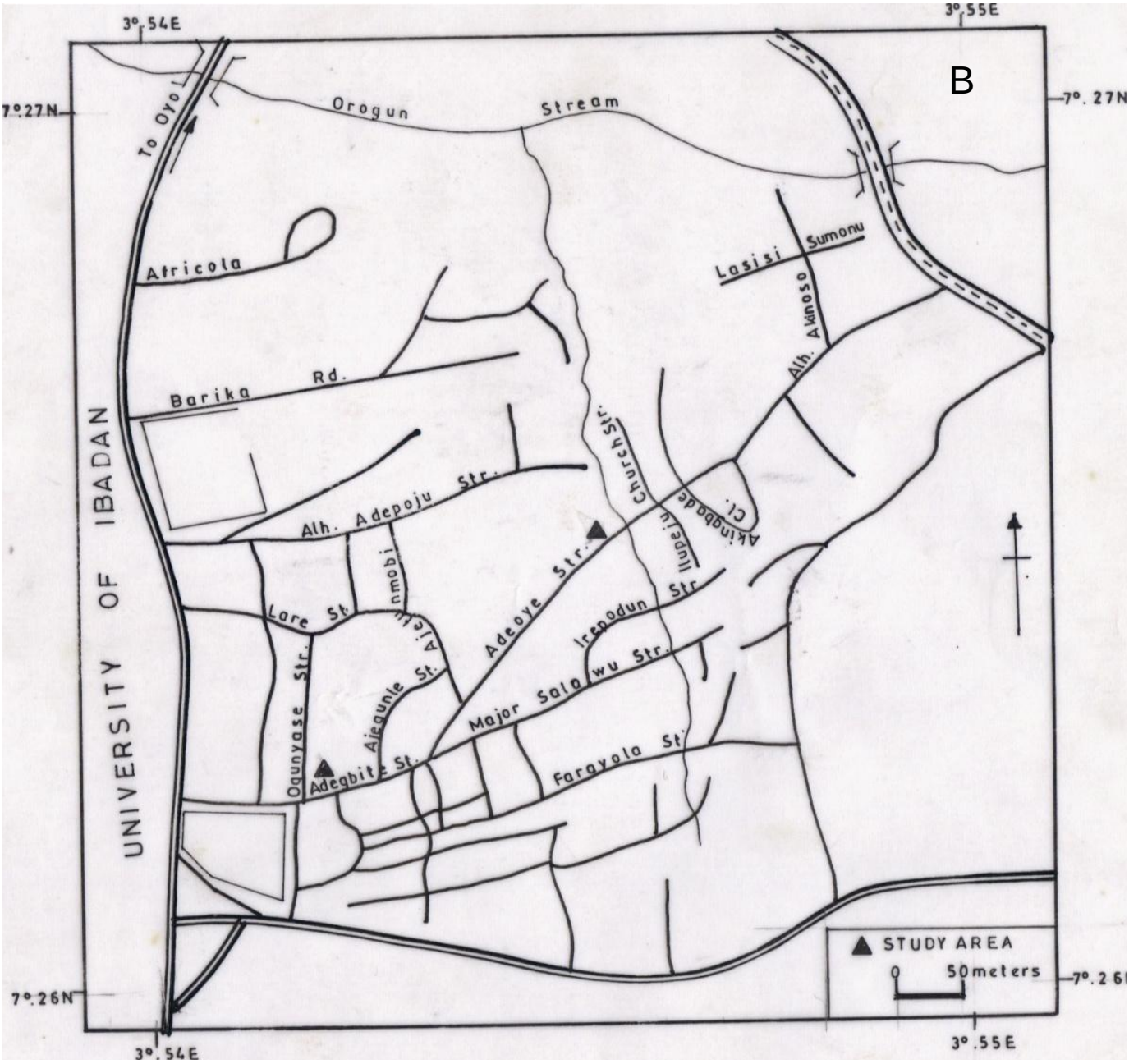

Figure 1B. Map showing the study areas (▲) within Agbowo, the University of Ibadan suburb community.

respectively).

DISCUSSION

The pH values for well, tap and borehole water samples from all the residences show that they were acidic as compared with the WHO permissible pH range guideline in drinking water of 6.5 to 8.5 (WHO, 2006). In fact the borehole water sample, which is the preferable drinking water source for the residential areas, has pH in the range 4.9 to 5.9 (Figure 2A).

The range of TDS for the water samples from wells (183 to 620 mg/L), taps (131 to 590 mg/L) and boreholes (129 to 409 mg/L) from all the study locations were below the WHO guideline value of 1,000 mg/L. The observed values therefore did not constitute any hazard for surface treated tap water, well water or deep groundwater (borehole)

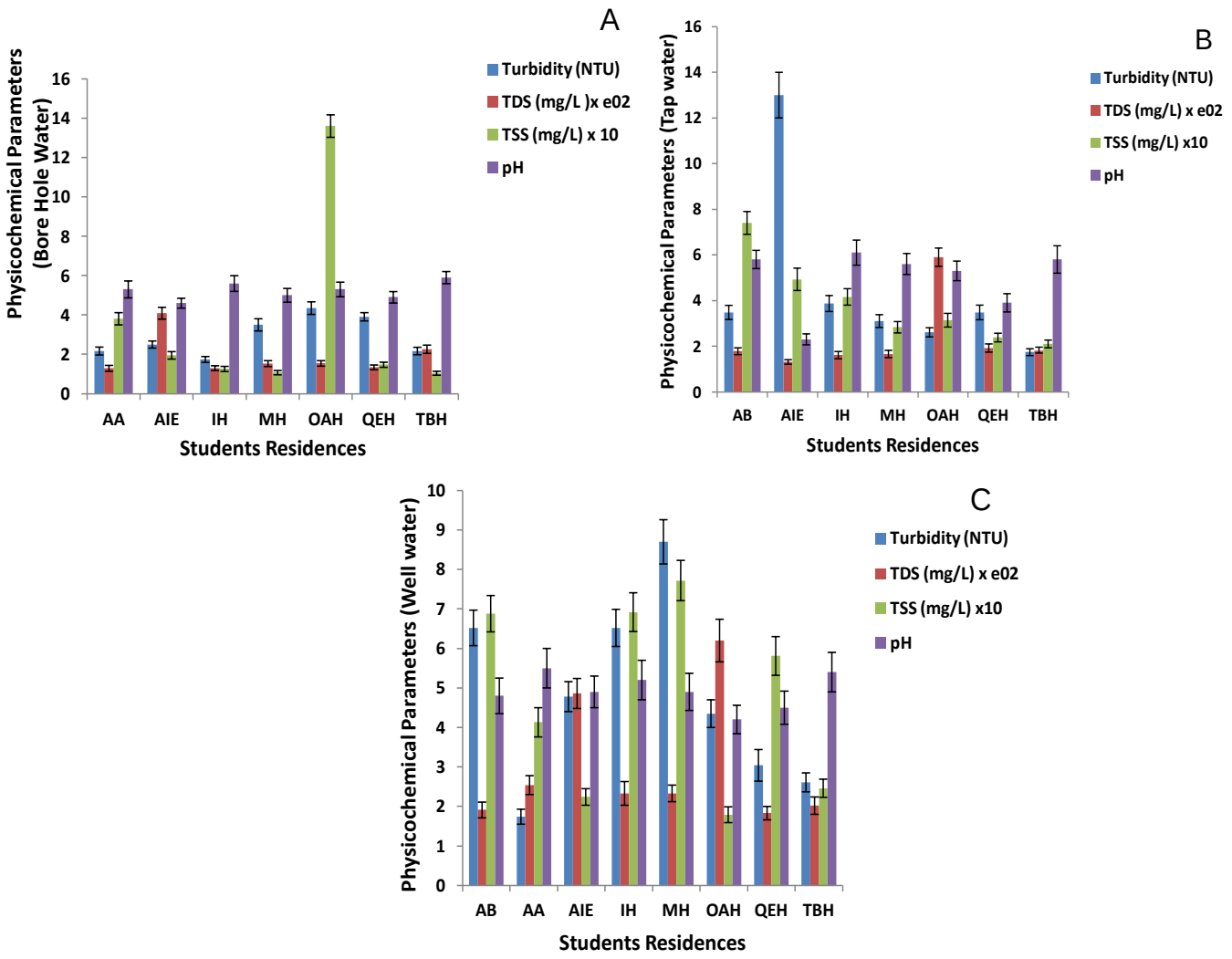

Figure 2. Physicochemical parameters [turbidity, total dissolved solids (TDS), total suspended substance (TSS) and pH] of source water of the university of Ibadan students' residences: Agbowo Adegbite Street (AA), Agbowo Ile-Eja (AIE), Independence Hall (IH), Mellanby Hall (MH), Obafemi Awolowo Hall (OAH), Queen Elizabeth Hall (QEH) and Tafawa Balewa Hall (TBH). (**A**) bore hole water, (**B**) tap water and (**C**) well water.

(borehole) sources in the students' residences. The TDS values of OAH tap (590 mg/L) and well (620 mg/L) water, even though lower than the WHO guideline value, are surprising and exceptionally higher than observed values for other water samples.

The observed mean Fe concentrations was in the order borehole < well water <tap water across all residential study areas. The borehole water samples have mean Fe concentrations that are within the USEPA standard value of 0.3 mg/L for Fe while the mean value for tap and well water samples exceeded USEPA standard in four residences. For instance, the mean value for tap water in QEH, AIE, IH and OAH was 0.585, 0.318, 0.472 and 0.348 mg/L, respectively. In addition, the mean value for well water samples in IH and OAH was 0.347 and 0.343 mg/L, respectively.

The Pb concentrations in all the water samples (well, tap and boreholes) exceeded the USEPA maximum contaminant level (MCL) of 0.015 mg/L for Pb in drinking water (USEPA, 2009). Mean Cd concentrations fell within the range of 0.001 to 0.004 mg/L for well as compared with the value of 0.002 to 003 mg/L for tap water and 001 to 0.003 mg/L for borehole. Mean Cd levels for all the water samples were therefore all within the USEPA MCL of 0.005 mg/L.

Of the three heavy metals studied, Fe and Pb levels were found to be above the USEPA permissible limits. The highest concentrations of Fe most glaringly above USEPA permissible limit were found in the tap water at QEH and IH (0.585 and 0.472 mg/L, respectively). They

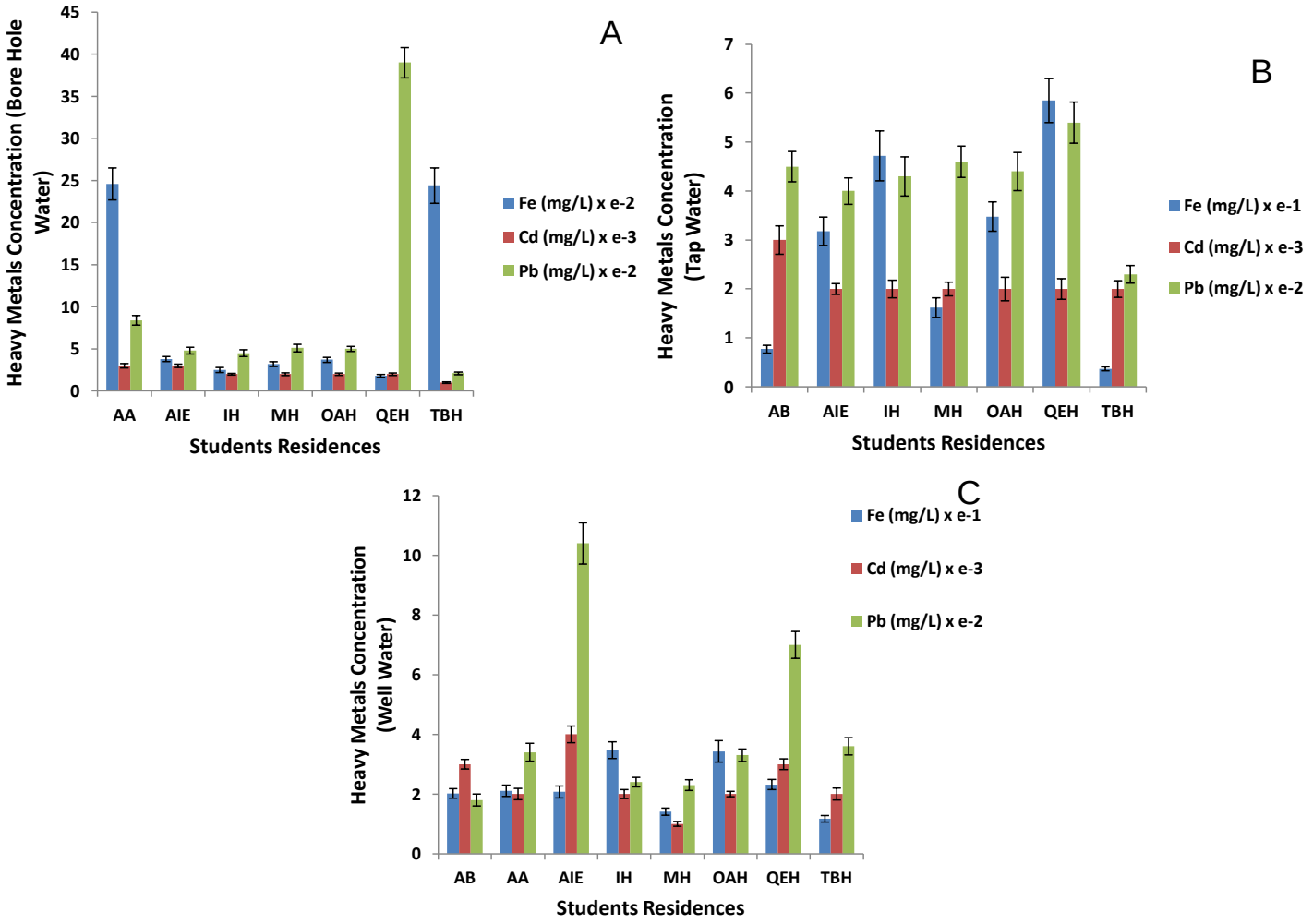

Figure 3. Levels of heavy metals [Iron (Fe), Cadmium (Cd) and Lead (Pb)] in the **(A)** bore hole water, **(B)** tap water and **(C)** well water samples from students' residences: Agbowo Adegbite Street (AA), Agbowo Ile-Eja (AIE), Independence Hall (IH), Mellanby Hall (MH), Obafemi Awolowo Hall (OAH), Queen Elizabeth Hall (QEH) and Tafawa Balewa Hall (TBH).

therefore constitute a serious health risk if this water is taken as drinking water sources. The borehole water in all the residences do not constitute any health risk as drinking water in terms of the concentration of Fe which fell within USEPA limit. Lead is a health risk factor for all of the water sources in the residences.

The possible sources of the contaminating heavy metals are old rusting galvanised lead containing pipes for bore hole and tap water. On the other hand, agrochemicals leachate of distance past and recent farming activities, agrochemicals washed in erosion, and residue from detergent contaminations of student community use are likely sources of well water contamination. The findings that mostly Pb and Fe constitute the contaminant at levels far above USEPA MCL suggest that most of the contamination were predominantly through the pipe carrying water pumped to the residences. It is therefore pertinent that the authorities would consider replacing the old galvanised water pipes with PVC types.

Conflict of Interest statement

The authors declare that there are no conflicts of interest.

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