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Comparative Analysis of the RADWQ Report and Academic Literature on the Quality of Water in Nigeria.

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Abstract
This paper compares analyses of water quality in Nigeria presented in the academic literature with that reported by the Joint Monitoring Programme (JMP) by the World Health Organisation (WHO) and United Nations International Children's Emergency Fund (UNICEF) in the Rapid Assessment of Drinking Water Quality (RADWQ) programme. Bibliographic and grey literature databases were used to identify studies of microbial and physicochemical water quality in Nigeria. We screened 521 study abstracts and identified 90 relevant studies based on 11,648 water samples. For each relevant study, we recorded the number of water samples, the location/hydrological areas and the water source that was analysed. The percentage compliance for the academic literature with the WHO guideline for each of these parameters was obtained and compared to the RADWQs result. We then analysed these results with the same method used for the RADWQ report to compare results from both studies. We found little variation in physicochemical results between the two studies, but a large difference between the identified microbial properties. The overall national average compliance with the WHO guideline value for the academic literature is 53.37%, while that for RADWQ project was 73%. These disparities could be attributed to the huge difference in the total number of water samples analysed, the high level of contamination in the water samples and most notably, the non-representativeness of the water samples in the hydrological areas.
Keyword: water quality, microbial properties, physicochemical properties, WHO RADWQ

1. Introduction

Poor water quality is a global issue, with poor sanitation and hygiene accounting for over 1.7 million world-wide deaths per year: 3.1% of all deaths and 3.7% of all Disability-Adjusted Life Years {DALY's} (Ashbolt, 2004). The precise problems vary across the world: some nations, predominately in the developed world, have worked to secure a sustainable supply of clean fresh water for public consumption, while many, predominantly the under-developed and developing countries, continue to struggle for access to safe water and sanitation.

Payment *et al.,* (1997) reported in their prospective epidemiology study of gastrointestinal health effects due to the consumption of drinking water, that between 14 and 40% of gastrointestinal illness can be attributed to tap water not meeting the current standards, with 2-5 years old being the most affected. Cabral *et al*., (2009) further elucidated that drinking unsafe water is the major cause of child mortality in India and it is estimated to cause over 0.5 million deaths annually. In a study done by Carlton *et al.,* (2012) in China, to estimate diseases attributed to unsafe water and poor sanitation, results showed that about 327 million people in China lacked access to piped drinking water and 535 million people lacked access to improved sanitation. They also observed that unsafe water and poor sanitation accounted for 2.81 million DALYs and 62, 800 deaths in the country that same year, with 83% of the attributable burden found in children less than five years old.

It is presently estimated that 783 million people in the world still lack access to safe drinking water, and 2.5 billion people still lack improved sanitation (WHO/UNICEF JMP 2012). According to the WHO/UNICEF JMP (2012), sub-Saharan Africa faces the greatest challenge in increasing the use of improved drinking-water facilities, with over 40% of all the people who globally lack access to drinking water currently residing in sub-Saharan African.

The WHO listed Nigeria as one of the world's top ten most populous countries without access to an improved drinking water source (WHO/UNICEF JMP, 2012). The Millennium Development Goal progress report by WHO/UNICEF JMP (2012), showed that Nigeria will not meet either the MDG's target for the estimated use of improved sanitation facilities, nor the target for improved drinking water sources by 2015 (see Table 1). Despite the announcement in March 2012 by UNICEF and WHO that the world has met the Millennium Development Goal (MDG) target of halving the proportion of people without sustainable access to safe drinking water, well in advance of the MDG 2015 deadline, it is still clear that over 783 million people are still without access to safe drinking water and billions without sanitation facilities (WHO/UNICEF JMP, 2012).

Between October 2004 and April 2005, the WHO/UNICEF conducted a pilot project, the Rapid Assessment of Drinking-water Quality (RADQW), which intended at testing a quick, low-cost method for assessing drinking-water

quality in the field (with an emphasis on the types of improved water source) and safety to determine how the Joint Monitoring Programme could be modified to take drinking-water safety into account. The RADWQ project was conducted in eight different countries and the summary report of these studies carried out in Jordan, Nigeria, Nicaragua Ethiopia and Tajikistan are available online. This project assessed each of the water sources using a checklist of potential risk factors and tested for a restricted set of water quality parameters (RADWQ, 2010; Bain *et al*., 2012). The Nigerian states was grouped into the eight hydrological areas and some states were chosen from within each hydrological areas, based on location of the state in the hydrological area, the population served, potential for water-quality hazards and the technological options (RADWQ, 2010). The RADWQ project analysed a total of 1841 water samples. In Nigeria, the water sources were tested for the presence of thermotolerant coliform bacteria (TTC), faecal streptococci (FS), iron, conductivity, pH, turbidity, fluoride, arsenic and nitrate compounds. The RADWQ data obtained were used to determine percentage compliance of the water source and the parameters with the WHO drinking water guidelines values. Thus, this paper aims also to determine the percentage compliance of these parameters from the academic literatures and to also compare the results with the WHO RADWQ results. These results will be subdivided by the water source type and by hydrological area.

2. Study Area

Nigeria is situated in West Africa, approximately located between latitude 4° and 14° North of the Equator, and between longitudes 2° 2' and 14° 30' East of the Greenwich meridian. It has a large land area of over 923,770 square kilometres and it is bordered to the north by the Republics of Niger and Chad, to the south by the Atlantic Ocean, to the east by the Republic of Cameroon and to the west by the Republic of Benin (Helmer and Hesanhol, 1997; BGS, 2003). Nigeria is the most populated country in Africa, with about a quarter of the total population of all the countries in the Sub-Sahara Africa. With a population of over 130 million people, Nigeria has the eighth largest national population in the world (Helmer and Hesanhol, 1997; BGS, 2003).

The climate of Nigeria varies from arid in the north to equatorial in the south to tropical in the centre. Nigeria's climate affects the quantity and quality of the country's water resources. This occurs as a result of two main wind systems: the hot, dry, dusty wind which blows from the north-east across the Sahara desert, which brings dry weather and dust-laden air and the relatively cool, moist, monsoon wind which blows from the south-west across the Atlantic Ocean towards the country which is accompanied by rainfall. Annual rainfall in Nigeria varies from 250mm in the north to over 4000mm in the south, with a national average of 1180mm. Rainfall in Nigeria is seasonal, with wet season ranging from March to September/October and the dry season ranging from November to February. The annual mean temperature is around 25 and 30 °C (77 and 86 °F) (Helmer and Hesanhol, 1997; Carter and Alhassan, 1998; Alagbe, 2002; BGS, 2003).

3. Methodology

Search strategy and selection criteria

The term 'water quality in Nigeria' was searched for in bibliographic databases and grey literatures. These searches covered the period until 10 October and 1 November 2012. Where the full text of a potentially relevant paper was unavailable, we contacted one or more authors. The search strategy and study selection results showed that 90 studies were systematically selected for this work and their characteristics are shown in figure 2. Of the 90 different reports, 5 of them worked on arsenic, 55 of them worked on conductivity, 7 of them also worked on fluoride, 48 of them worked on iron, 64 on nitrate, 81 on pH, 38 on turbidity, 39 on TTC, and 11 on FS (appendix).

Furthermore, the percentage compliance with the WHO Guideline values for each of the relevant studies was obtained, and then they were grouped into various parameters (i.e. Arsenic, Fluoride, TTC etc.). Each of the parameters were then categorised with respect to the hydrological area (figure 1) and source types (boreholes, wells etc.), then the national average for each hydrological area and water source type was obtained. The overall average compliance for the studies was then calculated.

4. Results

Nitrates

The overall compliance of Nigerian water supplies with WHO guidelines value for nitrate in the literatures and the RADWQ study is 92.38% and 90% respectively (table 2 and figure 3). Although the total water samples analysed for nitrate in the RADWQ study and the literatures are 631 and 6247 respectively, with most of the water samples analysed in the literatures coming from surface water. The need for its WHO guideline value (50mg/l) is mainly its link to methaemoglobinaemia of blue-baby syndrome (Osenbruck *et al*., 2006; Komor and Magner, 2012). Result

shows that the hydrological area 1 and 3 had the lowest compliance of 51% and 56% for the academic literatures and the RADWQ study respectively (table 2) and this could be attributed to the human activities and in particular from the disposal of human wastes and the use of inorganic fertilisers in agriculture close to the water sources. Hydrological area 6 had a total of 3471 and 318 water samples analysed for nitrate for this study and RADWQ study respectively, thereby making it the area with largest total water samples analysed for nitrate in both studies.

Thermotolerant coliform (TTC)

The overall compliance of Nigerian water supplies with WHO guidelines value for TTC in the literatures and the RADWQ study is 0.24% and 70% respectively (table 3 and figure 4). Although the total water samples analysed for TTC in the RADWQ study and this study is 1579 and 4427 respectively, with most of the water samples analysed in the literatures coming from surface water. The need for its WHO guideline value (0CFU/100ml) is mainly its link to faecal contamination of the water source, which may thereby lead to diarrhoeal diseases. Result further showed that almost all the water samples from all the hydrological areas in the literatures have been contaminated microbially (table 4) and this could be attributed to the human activities and in particular from the disposal of human and animal faeces to the water sources (Bradford *et al*., 2006; VanDerslice and Briscoe, 2012). Hydrological area 7 and 6 had a total of 2815 and 665 water samples analysed for TTC for the literatures and RADWQ study respectively, thereby making it the area with largest total water samples analysed for TTC in both studies. Also, it is seen that HA 2 and 3 had no studies reported (table 3).

Arsenic

The WHO guideline value limit for arsenic is 0.1 mg/l and excess of arsenic concentration in the human body could lead to carcinogenic effects (Boyle *et al*., 2010; Cho *et al*., 2010). The overall compliance of Nigerian water supplies with WHO guidelines value for arsenic in the literatures and the RADWQ study is 86.44% and 100% respectively (table 4 and figure 5). Although the total water samples analysed for arsenic in the RADWQ study and the literatures is 1608 and 59 respectively, it is evident that only two hydrological areas (i.e. HA5 and 6) had water samples analysed for in the literatures (table 4). This implies that this result may not be as reliable that of the RADWQ study because the RADWQ data are well spread around the hydrological areas.

Conductivity

Although little or no direct health risk has been associated with conductivity, but at high values the taste of water could be affected, thus the WHO placed a guideline value of 1,400 µS/cm. Table 5 and figure 6 showed that the overall percentage compliance for the literatures and RADWQ study is 96.20% and 98%. The HA6 also gave the hydrological area in which the largest studies were carried out in both studies.

Fluoride

The lack of fluoride is usually associated to dental caries, while an excess of fluoride is also associated with dental and skeletal fluorosis which may cause severe deformation and disability in susceptible individuals (Scanlon *et al.,* 2009; Syme and Williams, 2012). These among other effects made the WHO placed a guideline value of 1.5mg/l in a standard drinking water. The overall compliance of Nigerian water supplies with WHO guidelines value for fluoride in this study and the RADWQ study is 100%% and 97% respectively (table 6 and figure 7), although the total number of samples for the RADWQ study and this study is 1569 and 98 respectively. The tables also showed that a more representative sample was seen in the RADWQ study because fewer studies were observed from the academic literatures.

pH

The WHO guideline limit for pH is 6.5-8.5. The overall compliance of Nigerian water supplies with WHO guidelines value for pH in the academic literatures and the RADWQ study is 63.75%and 56% respectively (table 7 and figure 8). Although the total water samples analysed for pH in the RADWQ study and literatures is 1608 and 1406 respectively, with HA6 having most of the water samples analysed in both studies.

Faecal streptococci

The WHO guideline value for the level of faecal streptococci in a drinking water is 0CFU/100ml and all the water samples from the literatures showed that all the water samples are contaminated. The overall compliance of FS in the

literatures and RADWQ study is 0.20% and 78% respectively (Table 8), with the total number of water samples in the literatures and RADWQ study being 2962 and 172 respectively. Although, all the results from the literatures were obtained from the hydrological area 6 and 7, while that for RADWQ study was quite more representative in most of the areas.

Turbidity

The overall compliance of Nigerian water supplies with WHO guidelines value for turbidity in the literatures and the RADWQ study is 40.18% and 61% respectively (table 7 and figure 10). Also, the total water samples analysed for turbidity in the RADWQ study and the literatures are 1606 and 1846 respectively, with most of the water samples analysed in the literatures coming from surface water. The WHO guideline value for a standard drinking water is 5 NTU.

Iron

The WHO guideline value for standard drinking water is 0.3mg/l. The overall compliance for iron in the literatures and RADWQ study is 23.58% and 91% respectively, while the highest number of water samples was observed in hydrological area 6 with 2967 for the literatures and 693 for the RADWQ study (table 10). It is also observed from this study that HA1 and 3 had the highest compliance with the WHO guideline value of iron (table 10), while HA3 had the highest compliance in the RADWQ study.

5. Discussion

The results from the overall compliances with the WHO guideline values showed that some of the parameters such as conductivity, arsenic, fluoride, nitrate and pH have their results quite close (see figures 6, 5, 7, 3 and 8), while other parameters such as TTC, FS, turbidity and iron have a huge disparity (see figures 4, 9, 10 and 11). These results further confirm that the water quality of Nigerian water supplies is not on track to meet the MDG on drinking water.

These disparities could be attributed to the huge difference in the total number of water samples analysed, the high level of contamination in the water samples from different hydrological areas and the numerous water sources that were analysed. Despite the disparity, it could be seen that almost all the water samples analysed are microbially contaminated in both studies and since the presence of these micro-organisms in drinking water indicates that the water sources are contaminated by faeces, therefore indicating the urgent need for improved sanitation facilities. From the results, it could be seen that some of the hydrological areas do not have studies on them (especially in HA 3 and 4), this implies that research on the quality of water needs to be seriously extended to the rural part of the country where the main issue of water scarcity really occurs.

Another reason for the huge discrepancy in some of the parameters could be attributed to the difference in the type of water sources analysed. For the RADWQ study, an improved type of water source was used for analysis and this includes protected hand dug wells, protected boreholes, utility piped water and vehicle tanker, while for this study, it was observed that both the improved and non-improved water sources were analysed and this includes the protected and non-protected hand dug wells, protected and non-protected boreholes, rainwater, surface water, sachet and bottled water. This thus, causes a huge difference between the result for RADWQ study and the academic literatures. Furthermore, although the RADWQ study might have analysed the water samples by using an improved sources only, research has estimated that 48% of Nigerians (about 67 million) make use of surface water for their needs (FGN, 2007; Longe *et al*., 2010). It is therefore important that more improved water sources should be constructed in the hydrological areas where dependency on surface water is high.

The total number of water samples analysed both in the literature study and the RADWQ project was 11,648 and 1841 respectively. The huge difference in the total number of water samples analysed was also a major reason for the difference in the results. Furthermore, results showed that both studies are not very representative of the hydrological areas. For example, in the analysis of arsenic from the literatures, it is seen that only 59 water samples were analysed in only two hydrological areas (i.e. 5 and 6). Also in the analysis of faecal streptococci in the literatures, results further showed that about 2962 water samples were analysed in only hydrological areas 6 and 7. These examples show that more water quality testing needs to be carried out in different hydrological areas in Nigeria despite the tests that has been done.

The findings of this research have shown that there has been different water quality testing carried out by individual researchers from different universities, research institutes, Government agencies and some other organisations on different water sources. Some of these testing might have been done haphazardly, done for short term basis and/or

based on the reagents and equipment available to the individual (Arowolo *et al*., 2012). These reasons may have also caused some of the huge differences between the results obtained.

6. Conclusion

This paper have reviewed and compared the WHO RADWQ study with the academic literatures on the drinking water quality in Nigeria. Results showed that although some parameters such as conductivity, arsenic, fluoride, nitrate and pH had results which were quite close, while some parameters such as TTC, FS, turbidity and iron had a huge disparity in the results. This study further show the areas in Nigeria where more water quality investigation needs to be done. In order for Nigeria to meet the MDG by 2015, it is imperative that different sources of water (either improved or non-improved) are given more attention either in terms of water quality monitoring or construction. Also, effective water monitoring quality agencies strictly saddled with the sole responsibility of assessing the quality of water from different sources should be established, so as to create instant solution ranging from providing on-site treatment to shutting down of some water sources which are too harmful to human health.

In view of the foregoing, more attention should be given to the water sector in Nigeria. Since the three tiers of government (i.e. the Federal, State and Local government) are involved in ensuring that the public uses safe water, it is important that the responsibilities among them are well defined to enable them effectively protect the public's health.

7. References

Alagbe, S.A. (2002). Groundwater resources of river Kan Gimi Basin, North-Central, Nigeria. *Environmental Geology*, 42, 404-413.

Arowolo, T.A. Taiwo, A.M., Olujimi, O.O., and Bamgbose, O. (2012). Surface Water Quality Monitoring in Nigeria: Situational Analysis and Future Management Strategy, Water Quality Monitoring and Assessment, Kostas Voudouris and Dimitra Voutsa (Ed.), ISBN: 978-953-51-0486-5

Bain, R.E.S, Gundry, S.W, Wright, J.A., Yang, H., Pedley, S. and Batram (2012). Accounting for water quality in monitoring access to safe drinking-water as part of the Millennium Development Goals: lessons from five countries. *Bulletin of the World Health Organization* 2012; 90:228-235A. doi: 10.2471/BLT.11.094284

BGS (2003). Groundwater Quality: Nigeria. *British Geological Survey*. NERC

Boyle, K.J., Kuminoff, N.V., Zhang, C., Devanney, M. and Bell, K.P. (2010). Does a property-specific environmental health risk create a "neighborhood" housing price stigma? Arsenic in private well water. *Water resources research, 46(3),* W03507, doi:10.1029/2009WR008074.

Bradford, S. A., Simunek, J. and Walker, S. L. (2006), Transport and straining of E. coli O157:H7 in saturated porous media, *Water Resour. Res*., 42(12); W12S12, doi:10.1029/2005WR004805.

Cabral, C., Lucas, P. and Gordon, D. (2009). Estimating the health impacts of unsafe drinking water in developing country context. Aquatest Working Paper No. 01/09

Carlton, E.J., Liang, S., McDowell, J.Z., Li, H.Z., Luo, W. and Remais, J.V. (2012). Regional disparities in the burden of disease attributable to unsafe water and poor sanitation in China. *Bull World Health Organ.* 2012 August 1; 90(8): 578–587.

Carter, R.C. and Alhassan, A.B. 1998. Groundwater, soils, and development in the oases of the Manga grasslands, northeast Nigeria. In: *Hydrology in a Changing Environment*, eds: Wheater, H. and Kirby, C. *Proceedings of the British Hydrological Society*, Exeter, July 1998, pp 205-211.

Cho, Y., Easter, K.W. and Konishi, Y. (2010). Economic evaluation of the new U.S. arsenic standard for drinking water: A disaggregate approach, *Water Resour. Res.,* 46(10); W10527, doi:10.1029/2009WR008269.

FGN (2007). Legal Notice on Publication of the 2006 Census Report. *Federal Government of Nigeria official Gazette*, 4(94), 1-8.

Helmer, R. and Hesanhol, I. (1997). Water Pollution Control: A Guide to the Use of Water Quality Management Principles. The United Nations Environment Programme, the Water Supply & Sanitation Collaborative Council and the World Health Organization, E. & F. Spon, ISBN 0 419 22910 8

Komor, S.C. and Magner, J.A. (2012). Nitrate in Groundwater and Water Sources used by Riparian Trees in an Agricultural Watershed: A Chemical and Isotopic Investigation in Southern Minnesota. *Water resources research,* 32(4): 1039-1050

Longe, E.O., Omole, D.O., Adewumi, I.K. and Ogbiye, A.S. (2010). Water resources use, abuse and regulations in Nigeria. *Journal of Sustainable Development in Africa*. 12(2).

Osenbruck, K., Fiedler, S., Knoller, K., Weise, S. M., Sultenfuß, J., Oster, H. and Strauch, G. (2006), Timescales and development of groundwater pollution by nitrate in drinking water wells of the Jahna-Aue, Saxonia, Germany, *Water Resour. Res.,* 42(12), W12416, doi:10.1029/2006WR004977.

RADWQ (2010). Rapid Assessment of Drinking-water Quality in the Federal Republic of Nigeria: Country Report of the Pilot Project Implementation in 2004-2005.

Scanlon, B. R., Stonestrom, D. A., Reedy, R. C. Leaney, F. W., Gates, J. and Cresswell, R. G. (2009), Inventories and mobilization of unsaturated zone sulfate, fluoride, and chloride related to land use change in semiarid regions, southwestern United States and Australia, *Water Resour. Res*., 45(7); W00A18, doi:10.1029/2008WR006963.

Syme, G.J. and Williams, K.D. (2012). The psychology of drinking water quality: An exploratory study. *Water resource research*. 29(12); DOI: 10.1029/93WR01933

VanDerslice, J. and Briscoe, J. (2012). All coliforms are not created equal: A comparison of the effects of water source and in-house water contamination on infantile diarrheal disease. *Water Resour. Res*., 29(7); 1983-1993.

WHO/UNICEF JMP (2012). WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation estimates for the use of Improved Sanitation Facilities and Improved drinking water sources in Nigeria. http://wssinfo.org (Accessed on 10/10/2012).

Table 1: Progress towards the MDG drinking water and sanitation target

Country, area or territory	Drinking water coverage (%) (1995 estimates given in red)		MDG Target (%)	Required coverage in 2010 if country was on-track in 2010 (%)	MDG progress assessment for 2010	Sanitation coverage (%) (1995 estimates given in red)		MDG Target (%)	Required coverage in 2010 if country was on-track in 2010 (%)	MDG progress assessment 2010
	1990/1995	2010	2015			1990/1995	2010	2015		
Nigeria	47	58	74	68	Not on-track	37	31	69	62	Not on-track

Source: WHO/UNICEF JMP (2012).

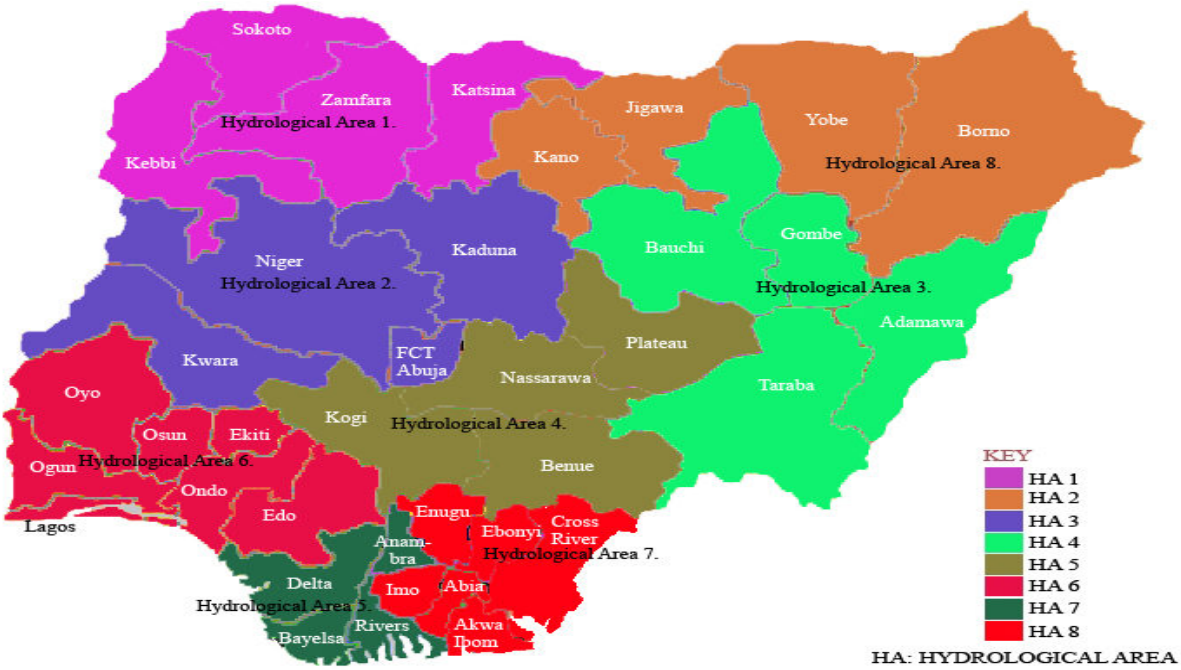

Figure 1: Map of Nigeria showing different states and the hydrological areas.

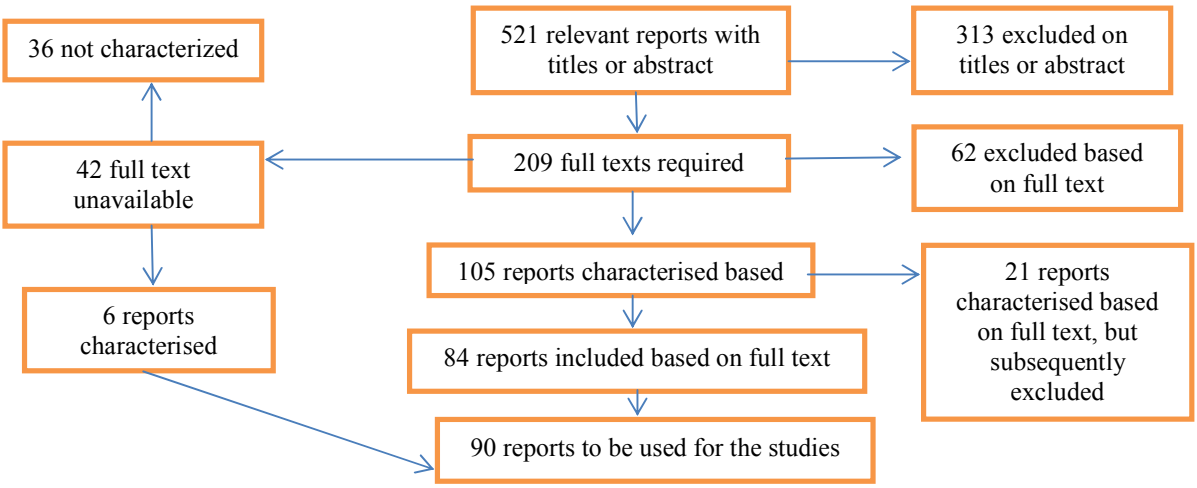

Figure 2: Flow diagram, showing how studies were selected for inclusion in the review

Table 2: Percentage compliance of Nigerian water supplies with WHO guideline value for Nitrates

HA	RADWQ study	Literatures
HA1	88%	51%
HA2	100%	100%
HA3	56%	
HA4	71%	100%
HA5	100%	100%
HA6	92%	88.99%
HA7	100%	97.20%
HA8	99%	83.33%
NA	90%	92.38%

Source (RADWQ, 2010). HA = Hydrological Area NA = National average

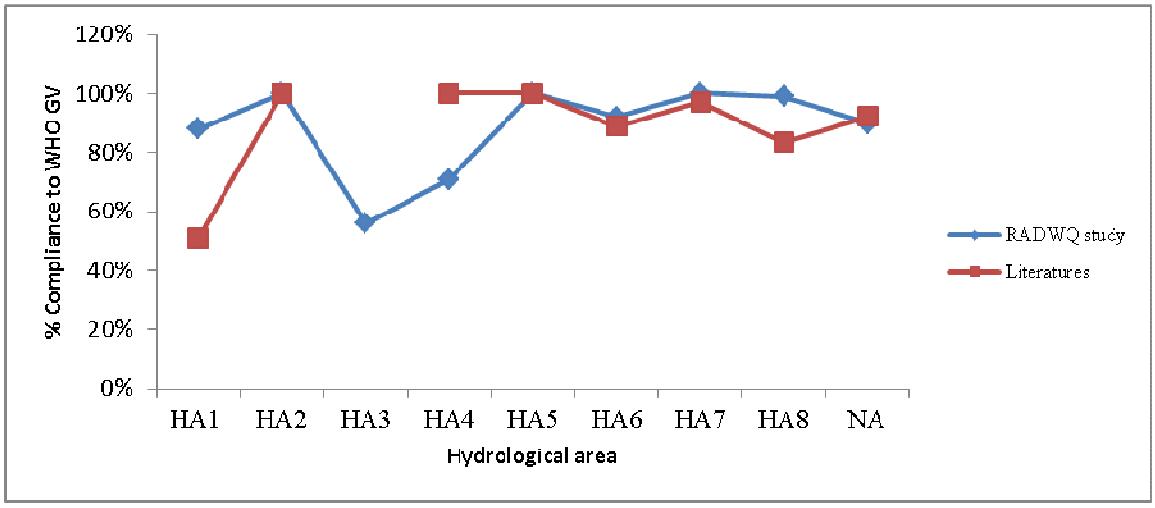

Figure 3: Comparative plot for the literatures and RADWQ study for Nitrate

Table 3: Compliance of Nigerian water supplies with WHO guideline value for TTC

HA	RADWQ study	Literatures
HA1	80.81%	0%
HA2	97.79%	
HA3	70%	
HA4	72.92%	0%
HA5	81.77%	0%
HA6	68%	1.04%
HA7	77%	0.07%
HA8	93.19%	0.00%
NA	77%	0.24%

Source (RADWQ, 2010). NA = National Average, HA = Hydrological Area, TTC = Thermotolerant coliform

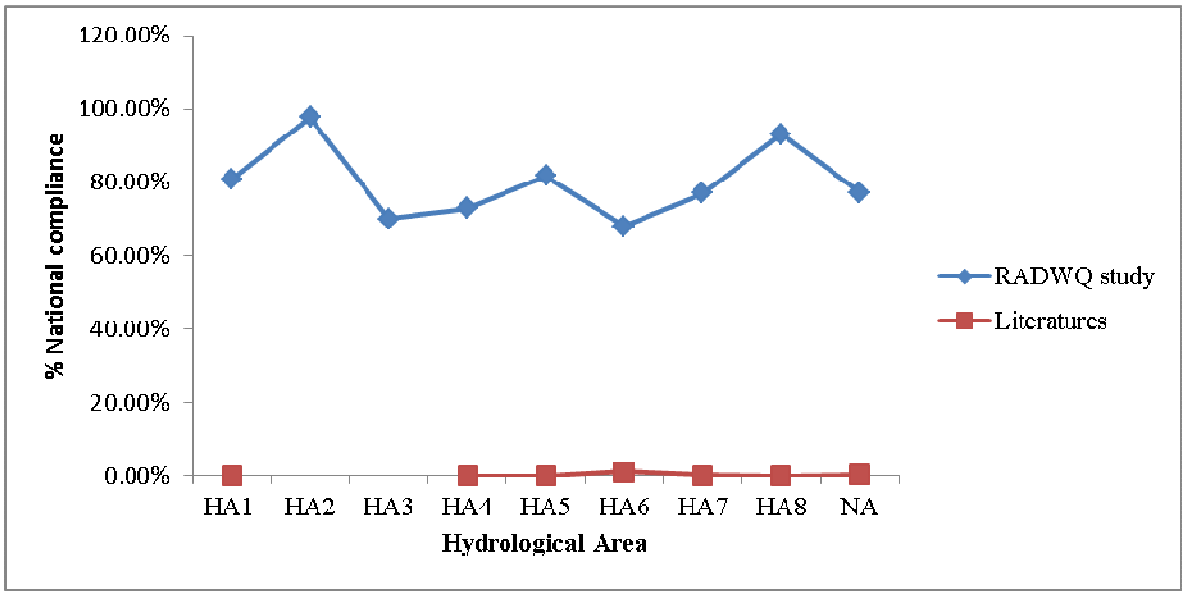

Figure 4: Comparative plot for the literatures and RADWQ study for TTC

Table 4: Compliance of Nigerian water supplies with WHO guideline value for arsenic

HA	RADWQ study	Literatures
HA1	100%	
HA2	100%	
HA3	100%	
HA4	100%	
HA5	100%	100%
HA6	100%	80%
HA7	100%	
HA8	100%	
NA	100%	86.44%

Source (RADWQ, 2010). HA = Hydrological Area NA = National average

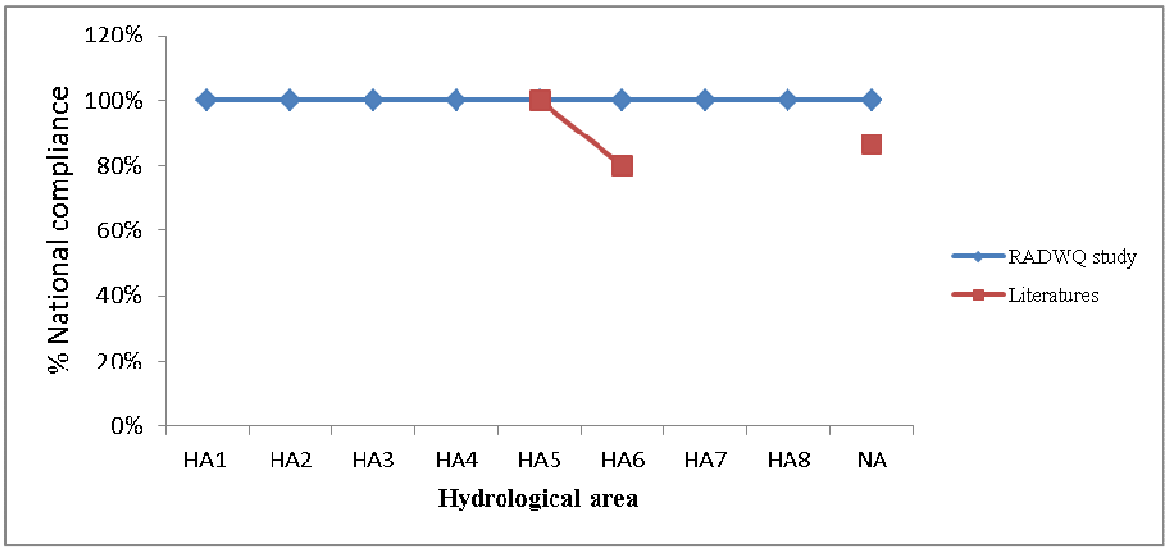

Figure 5: Comparative plot for the literatures and RADWQ study for Arsenic

Table 5: Compliance of Nigerian water supplies with WHO guideline value for conductivity

HA	RADWQ study	Literatures
HA1	98%	100%
HA2	100%	100%
HA3	80%	100%
HA4	96%	100%
HA5	99%	100%
HA6	99%	93.35%
HA7	100%	100%
HA8	100%	100%
NA	98%	96.20%

Source (RADWQ, 2010). HA = Hydrological Area, NA = National average

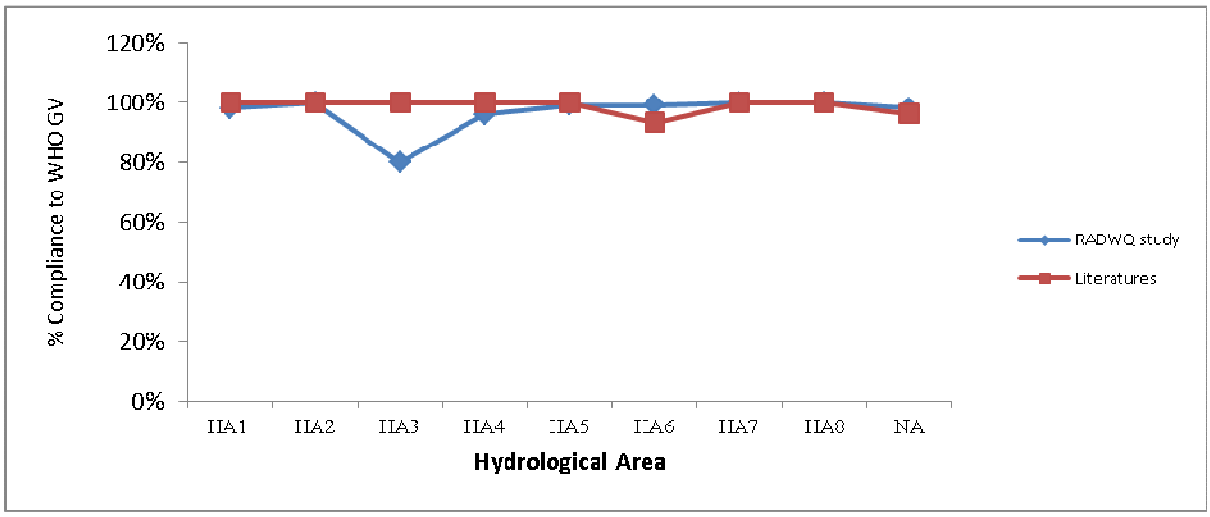

Figure 6: Comparative plot for the literatures and RADWQ study for conductivity

Table 6: Compliance of Nigerian water supplies with WHO guideline value for fluoride

HA	RADWQ study	Literatures
HA1	100%	100%
HA2	100%	100%
HA3	100%	100%
HA4	91%	
HA5	100%	
HA6	97%	100%
HA7	100%	
HA8	98%	
NA	97%	100%

Source (RADWQ, 2010). HA = Hydrological Area NA = National average

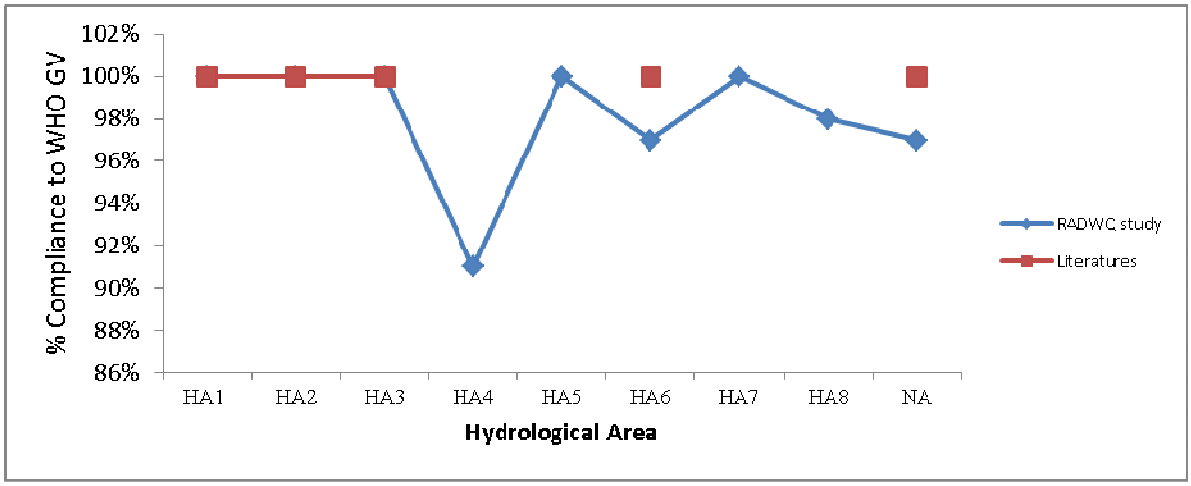

Figure 7: Comparative chart for the literatures and RADWQ study for fluoride

Table 7: Compliance of Nigerian water supplies with WHO guideline value for arsenic

HA	RADWQ study	Literatures
HA1	63%	50.51%
HA2	75%	56.45%
HA3	88%	90.40%
HA4	57%	40%
HA5	7%	20.78%
HA6	63%	81.60%
HA7	49%	29.88%
HA8	41%	
NA	56%	63.67%

Source (RADWQ, 2010). HA = Hydrological Area NA = National average

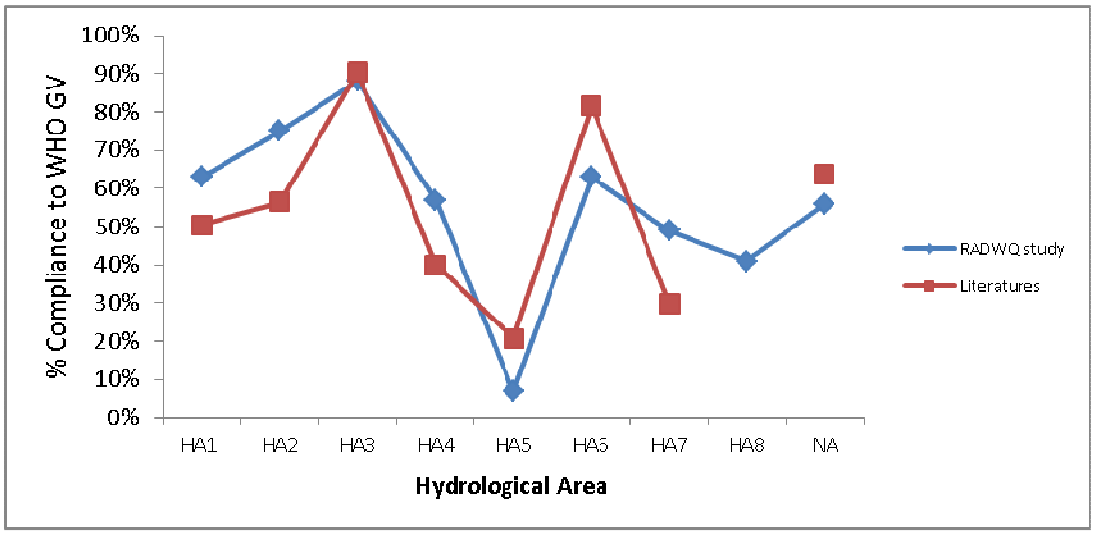

Figure 8: Comparative chart for the literatures and RADWQ study for pH

Table 8: Compliance of Nigerian water supplies with WHO guideline value for FS

HA	RADWQ study	Literatures
HA1	91%	
HA2	70%	
HA3	100%	
HA4	81%	
HA5	50%	
HA6	71%	1.78%
HA7	100%	0.00%
HA8	100%	
NA	78%	0.20%

Source (RADWQ, 2010). FS = Faecal streptococci HA = Hydrological Area NA = National average

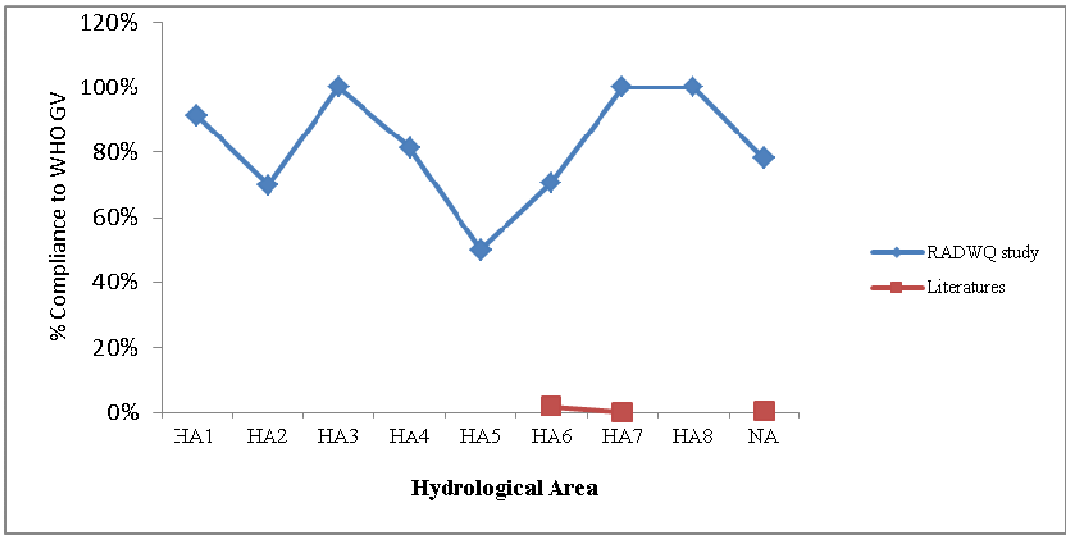

Figure 9: Comparative chart for the literatures and RADWQ study for FS

Table 9: Compliance of Nigerian water supplies with WHO guideline value for turbidity

HA	RADWQ study	Literatures
HA1	50%	
HA2	41%	0.00%
HA3	76%	93.08%
HA4	37%	
HA5	100%	28.71%
HA6	68%	32.65%
HA7	54%	100.00%
HA8	56%	0.00%
NA	61.00%	40.18%

Source (RADWQ, 2010). HA = Hydrological Area NA = National average

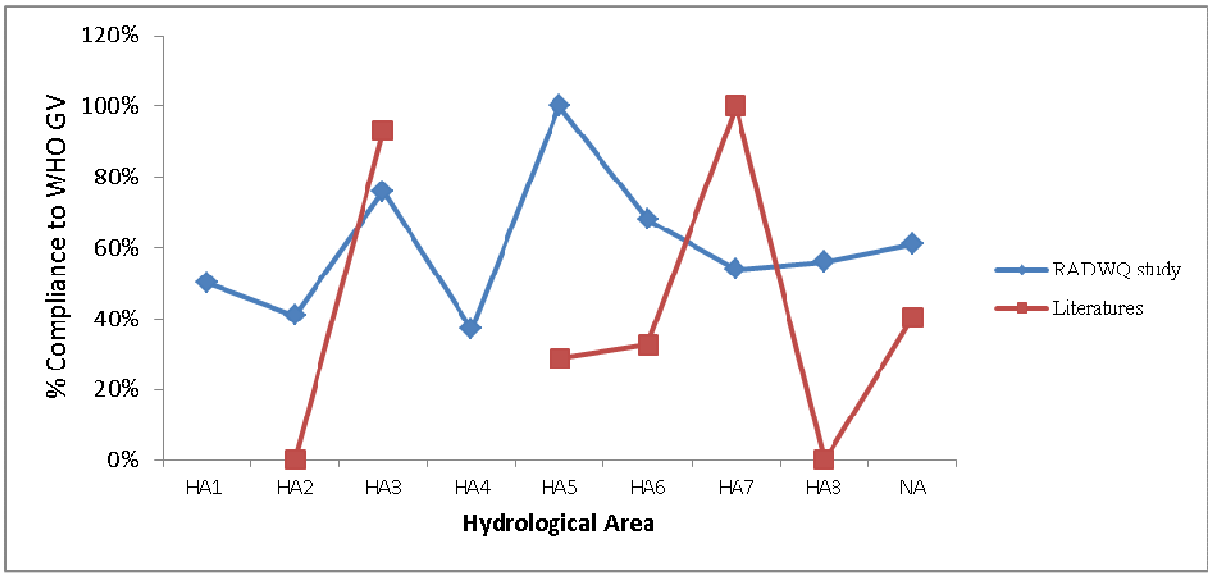

Figure 10: Comparative plot for the literatures and RADWQ studies for turbidity

Table 10: Compliance of Nigerian water supplies with WHO guideline value for iron

HA	RADWQ study	Literatures
HA1	94%	100.00%
HA2	99%	45.04%
HA3	100%	100.00%
HA4	77%	9%
HA5	94%	77.66%
HA6	94%	18.71%
HA7	91%	40.79%
HA8	87%	0.00%
NA	91.00%	23.58%

Source (RADWQ, 2010). HA = Hydrological Area NA = National average

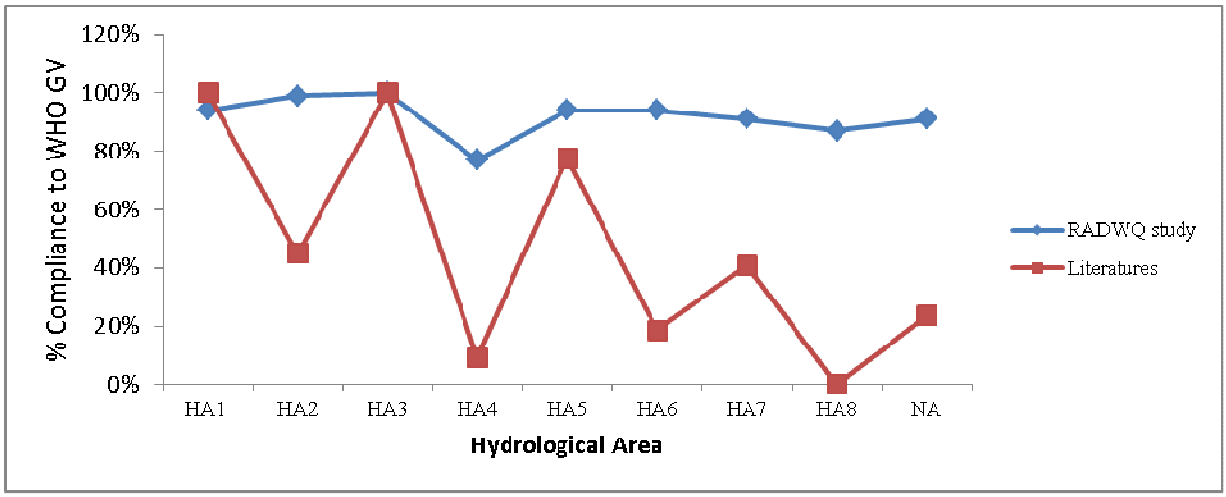

Figure 11: Comparative plot for the literatures and RADWQ study for Iron

Table 11: Summary of the overall percentage compliance for the RADWQ and the literatures

Parameters	RADWQ survey	The literatures
TTC	77%	0.24%
FS	78%	0.20%
Arsenic	100%	86%
Fluoride	97.10%	100%
Nitrate	89.90%	92.38%
Iron	91%	23.58%
Turbidity	61%	40.18%
Conductivity	98%	96.20%
pH	57.80%	63.75%
NA	73%	53.37%

NA = Overall national average

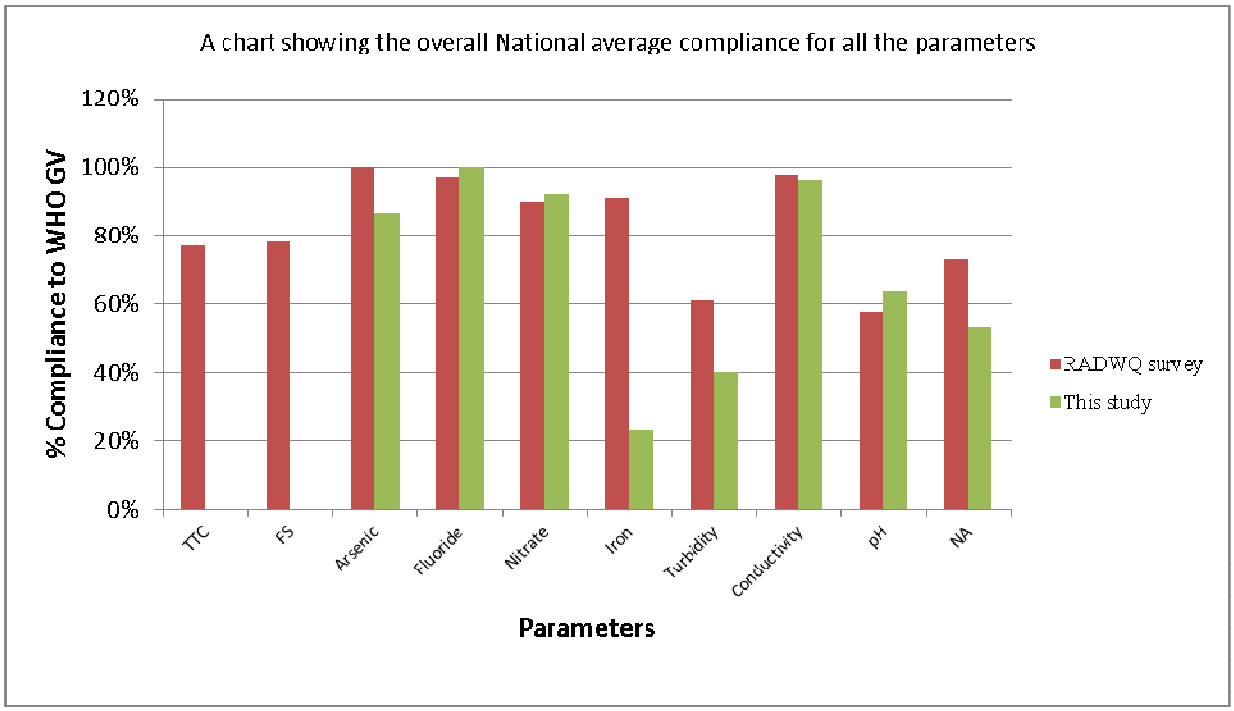

Figure 12: Overall compliance for all the parameters

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