EVALUATION OF PORTABLE WATER DEMAND AND SUPPLY IN HADEJIA PARTS OF SEMI-ARID REGION OF JIGAWA STATE

BY

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Abstract

This evaluation investigates the current state of potable water resources and analyzes demand patterns. The study employs a comprehensive methodology, incorporating data derived from structured questionnaires, field measurements, and laboratory analyses. Descriptive statistics were adopted for the analysis. The predominant sources of water supply within the study area were determined to be hand-dug wells, boreholes, rivers, and piped water. A comprehensive analysis of water demand patterns across the region revealed a daily household demand of 553,640 liters, surpassing the available supply of 321,423 liters. This daily deficit amounted to 232,217 liters. The primary sources of water supply contributed to the overall supply in the following proportions: boreholes (28.43%), hand pumps (20.77%), and hand-dug wells (20.27%). While the concentrations of Zn, Fe, Cu, and Mn in the water supply adhered to WHO guidelines, Pb, Cd, Cr, and Mg exceeded the recommended permissible levels. The MPI (presumably a measure of groundwater pollution) reveals a critical threat to groundwater resources, with recorded values exceeding the established threshold of 6.0the study recommends collaborative efforts between governmental entities and WASH-focused NGOs to ensure equitable access to potable water for all households, irrespective of their geographical location.

Key words: Evaluation, portable water, demand, supply and Semi-Arid region.

1.1 INTRODUCTION

In numerous regions worldwide, water demand currently exceeds supply, and this imbalance is projected to intensify as the global population continues to grow at an unprecedented rate (Gallandat et al., 2021). Moreover, water demand exhibits substantial regional and seasonal variations. Effective water resource development, conservation, and management hinge on a comprehensive understanding of water demand and supply. Adequate access to freshwater of sufficient quantity and quality is a fundamental prerequisite for sustaining human life and civilization (Agrawal et al., 2021). In many developing countries, particularly in semi-arid regions, the development and management of available surface water resources have been critical challengesin developing countries, the sustainable availability of potable and non-potable water remains a critical challenge (Douti et al., 2022). Research conducted by Sojobi et al. (2014) indicates that 40% of the global population lacks access to safe drinking water in Sub-Saharan Africa (SSA). The confluence of poor water governance, social inequality, population growth, and climate change in Africa raises concerns about the potential for 75-250 million people in the region to face increased water stress by 2020 (Kalungu et al., 2014).

Unless immediate and decisive action is taken to address Africa's current water challenges, the continent may confront a water crisis within the next decade (Distefano et al., 2017; Lazare et al., 2023). As highlighted by Oyebode et al. (2019), water supply in Nigeria, similar to many other developing countries, grapples with substantial challenges, often rooted in economic and socio-political factors. Population surges within developing nations have outstripped the capabilities of existing water infrastructure, leaving a significant portion of the population without adequate access to safe water (Shafiee et al., 2017). This challenge is compounded by the unreliability of water supply systems across Africa, as documented by Rached et al. (1996) and NEPAD (2006). Water resources are experiencing a growing scarcity, particularly in arid regions, due to the combined effects of climate change and escalating human water consumption driven by population growth and industrialization. The annual distribution of rainfall across Nigeria is uneven, with the northernmost regions receiving as little as 250 millimeters per year. various contaminants affecting water resources, heavy metals are of particular concern due to their high toxicity, even at low concentrations. The contamination of groundwater ecosystems with heavy metals is a global environmental challenge (Yahaya et al., 2019; Tsor et al., 2022). Trace element concentrations in water can vary depending on physiological, environmental, and other factors.

Globally, water scarcity is a growing concern, with over five billion people projected to face shortages by 2050 (Mancosu et al., 2015). In Hadeja, residents primarily cite irregular and unreliable water supply from local authorities as their chief water-related challenge, largely due to their reliance on communal taps. Survey respondents indicate that inconsistent supply is the most significant water-related issue, followed by distance and wait times (Bello et al., 2023). This study will assess water demand, its suitability, and the adequacy of current water supply, identifying key constraints in potable water supply. It will also contribute to academic knowledge by providing insights into rural water demand and supply patterns.

1.2 Study Area and Methodology

The climate of semi-arid areas are highly variable with droughts, as well as irregular episodes of above average rainfall making water scarcity and salinity particularly insidious issues in these climates. Its terrain is characterized by undulating land and huge alluvial flats in the interdune area, with sand dunes of varying sizes stretching several kilometers in some areas of the state. Basement Complex dominates the southern half of Jigawa, while the Chad Formation dominates the northeast (Olofin, 1973; Ahmed, 2003). Hadejia town is located in eastern part of Jigawastate between latitude 12.45060N and longitude10.04040E. Thegeology of the study area is Chad formation withsemi-arid type of climate. It is characterized withlong dry season and a short-wet season andaverage annual temperature of 27°C. The totalannual rainfall ranges from 600mm to 762mmand falls within the Sudan Savannah with anextensive open grassland and few scattered trees (Olofin, 2016).

Methodology

The research utilized both qualitative and quantitative form of data sourced using questionnaire field measurement and laboratory analysis.Multistage sampling was used for this study; this involves sampling communities from which respondents were selected, and a questionnaire was administered. The technique essentially involves reducing the size of the study population to a convenient size but passing through several stages to ensure representation. The Hadejia Local Government consist of eleven (11) political wards, namely: Atafi, Dubantu, Gagulmari, Kasuwar

Ƙofa, Kasuwar Kuda, Matsaro, Majema, Rumfa, Sabon Garu, Yankoli and Yayari with a total population of approximately 105,628 (NPC, 2006). Projected to 179,300 in 2023.One hundred and seventy Nine (179) was randomly selected across the five communities for questionnaire administration.Neuman (2014) discoursed that taking just 0.1% of the population as a sample would give a good representation of such population, especially when the population is homogenous and has a large population above 100,000.The questionnaire elicited data on water supply sources, accessibility, time consumption, challenges, costs, and overall satisfaction. Experts in research design from the Department of Economics and Development Studies at Federal University Dutse validated the questionnaire's reliability and validity. Groundwater samples were collected using purposive sampling techniques, considering diverse locations and economic factors.

Water samples were collected from five diverse locations, including a river, tap water source, ponds, a borehole, and a hand-dug well, adhering to the standardized procedures outlined in APHA 2012. A total of fifteen groundwater samples were obtained. Upon collection, each sample was acidified with HNO3, labeled, stored at ambient temperature, filtered, and subsequently analyzed using atomic absorption spectrophotometry (AAS) (Greenberg et al., 1992).To evaluate the extent of heavy metal contamination and the suitability of the water for consumption, a metal index (MI) was calculated for each groundwater sample (Caerio et al., 2005). Descriptive statistical analysis was conducted on the collected data, and the results were compared against the World Health Organization's (WHO) guidelines (2006) to assess the water's suitability for human consumption within the study area.

1.3 RESULT AND DISCUSSION

The study identified several primary water sources: motorized boreholes, hand-dug wells, and hand pumps (groundwater sources); and rivers, ponds, and streams (surface water sources). Many respondents expressed a preference for public taps connected to government-developed boreholes, citing their accessibility, relatively high-water quality, and convenient location. The results indicated that 20.77% of respondents in Hadeja sourced their water from hand-dug wells, while 28.43% utilized surface water.

1.4 Main water supply in the study area

Table 2: Percentage Water supply in the study area

Sourcesof Water	Atafi	Gagulmari	Matsaro	Kasuwar Kofa	Rumfa	Total	%
Surface water	14,345	7,800	5,860	800	1,700	30,505	9.49
boreholes	20,400	13,000	27,300	19,000	11,708	91,408	28.43
Hand-dug well	11,630	10,800	11,750	17,800	14,800	66,780	20.77
Hand pump	10,050	13,070	11,600	15,100	13,810	63,630	19.79
water vendors	16,250	24,500	4,350	9,500	14,500	69,100	20.79
Total	72,675	69,170	60,860	62,200	56,518		

Source: Data Analysis 2024.

1.6 Water Demand pattern in the communities

Table 4 presents the distribution of water consumption for various domestic purposes within the study area. These purposes encompass drinking, sanitation, cooking, bathing, and other activities such as irrigation and livestock. The table reveals that drinking accounted for 17.63% of water consumption, sanitation for 21.49%, cooking for 15.80%, bathing for 14.24%, and other purposes, including gardening and livestock, for 30.62%.

Drinking: The study found that households in the study community consume an average of 97,610 liters of drinking water per day. Consumption varied, with Matsaro at 15,860 liters and Gagulmari at 26,800 liters. Household size and population density in high-density areas likely contribute to these variations.

Sanitation: Sanitation accounted for 21.49% of water consumption, including toilet, dishwashing, laundry, and floor cleaning. Kasuwar Ƙofa households used 39,000 liters daily for sanitation, compared to Gagulmari's 15,000. This variation is due to Kasuwar Ƙofa's more consistent borehole water supply. Across neighborhoods, households consumed an average of 119,000 liters of water per day for sanitation.

Cooking: The study analyzed water consumption for cooking in Hadejia. Table 4 indicates that 15.80% of domestic water was used for this purpose. On average, households consumed 87,780 liters of water per day for cooking across the neighborhoods.

Bathing: The study found that bathing accounted for 14.24% of domestic water consumption in Hadejia. Household water usage for bathing averaged 79,150 liters per day across the city. Gagulmari households exhibited the highest consumption at 19,000 liters per day, surpassing Atafi's 13,050 liters.

Others (livestock/gardening): The study also considered domestic water used in maintaining the livestock/garden in the respondents' compound. Table 4 shows that only 30.62% of the domestic water was used for livestock/gardening in the city. In addition, 170,100litres/day of domestic water was used on livestock/gardening per day.

1.7 Patterns of water demand and supply in the studyarea

Residents in some part of the study area often trekover long distances (between 1 and 2.5 km) toaccess the water they need. The spatial patterns of water demand characteristics for the entire area shows that thetotal household water demand is 553,640 lpd, against the total household water supply of 321,423lpd, leaving a daily deficit of 232,217 Lpd.

Table 4: Volume of water Demand for various purposes in litres per day (L/day)

Domestic Use	**Residential Areas (Communities)**						
	Atafi, Gagulmari, Matsaro, Kasuwar Ƙofa Rumfa					**Total**	**%**
Drinking	18,450	26,800	15,860	17,800	18,700	97,610	17.63
Sanitation	20,300	15,000	29,000	39,000	15,700	119,000	21.49
Cooking	13,630	13,800	21,750	21,800	16,800	87,780	15.80

Bathing	13,050	19,000	14,500	17,300	15,300	79,150	14.24
Others	27,250	34,500	24,350	39,500	44,500	170,100	30.62
Total	92,680	109,500	105,460	135400	111,000	553640	100

Source: Data analysis 2023

1.8Gap between water demand and supply in the study area

The study reveals a substantial disparity between water demand and supply in Hadejia, with an average daily deficit of 46,444 liters. Table 5 quantifies this discrepancy. Despite a relatively low average daily water demand of 110,728 liters, supply falls short at 64,284 liters. This indicates a significant shortfall in water access, with individual water consumption exceeding available supply.

Table 5 Gap between daily household water demand and supply in the study area

Communities	Water Demand in Litre	Water Supply in litre	Gap Between Demand and Supply in litre	% of water demand satisfied by supply
Atafi,	97,610	72,675	24935	17.63
Gagulmari,	119,000	69,170	49830	21.42
Matsaro	87,780	60,860	26920	15.80
Kasuwar Ƙofa	79,150	62,200	16950	14.25
Rumfa	170,100	56,518	113582	30.62
Mean	110,728	64284	46,444	-

1.9Heavy metals concentration in groundwater samples

The analysis of heavy metals concentration of groundwater samples along with WHO for human consumption are presented in Table 6.

Table 6: Heavy metals concentration in groundwater samples

Parameter	Atafi	Gagulmari	Matsaro	Kasuwar Kofa	Rumfa	Range	Mean	WHO Standard (2015)	ΣMPI
Pb	0.024	0.1	0.133	0.185	0.164	0.161	0.112	0.01	0.518
Zn	0.129	0.01	0.031	0.041	0.073	0.0119	0.049317	3.0	0.284
Cd	0.1	0.005	0.013	0.2	0.045	0.087	0.075	0.003	0.363
Cr	0.375	0.014	0.006	0.5	0.141	0.494	0.255	0.05	1.036
Mg	1	2.03	17.86	1.4	0.2	16.8	6.548333	0.05	22.49
Fe	0.185	0.96	1.82	3.259	0.102	1.561	0.814667	0.3	3.327
Cu	0.271	0.02	0.03	0.09	0.117	0.251	0.129833	0.01	0.528
Mn	0.1	0.022	0.044	0.18	0.5	0.456	0.217	30	0.846

Lead: Lead concentrations in the groundwater samples ranged from 0.024 to 0.165 mg/L, with an average of 0.112 mg/L, exceeding the WHO's permissible limit of 0.01 mg/L for drinking water. These findings align with those of Hassan et al. (2021), who identified elevated heavy metal levels in groundwater near industrial sites in Kano. The high lead concentration is likely attributable to anthropogenic activities in the area, such as excessive chemical use for agriculture and irrigation. Research suggests that prolonged exposure to lead (Pb) can increase the risk of various health problems, including anemia and hypertension (Jaishankar et al., 2014; Fisseha et al., 2016; Edokpayi et al., 2018).

Zinc:Zinc concentrations in the analyzed water samples ranged from 0.01 to 0.073 mg/L, with an average of 0.049317 mg/L, falling within the WHO's permissible limit for drinking water. These levels may be attributed to the leaching of chemicals and other particulates into the groundwater. The relatively low zinc concentration suggests a limited presence of fluorescent lamps and batteries in the area. These findings align with those reported by Gutti et al. (2014).

Cadmium:finding indicates Cadmium ranged from 0.013 to 0.2, and the average mean value of 0.075mg/l. The mean value of dissolved cadmium is higher than the permissible level of 0.003 mg/l. It may be due to the toxic effluent discharge from industrial areas of urban Kano, which may influence high levels of reported cadmium concentration. Equally importantleachate percolation contribute to that extent. A high concentration of cadmium may cause several damages, such as kidney damage and obstructive lung diseases(Horton *et al.,* 2013; Mohankumar*et al.,* 2016)

Chromium: In the present study, chromium concentration in groundwater samples gave the range values between 0.006 and 0.5 with a mean of 0.255mg/l, which is higher than the recommended limit by WHO guidelines for drinking water. The high concentration of chromium was more pronounced than the other trace metals. The maximum value obtained from this study could be sourced through septic systems or agriculturally oriented used chemical.

Magnesium: Magnesium concentration ranges between 0.2 and 17.86, with an average value of 6.548 mg/l. The value is above the acceptable limit recommended by WHO guidelines for human consumption. Magnesium is another essential mineral required to maintain the proper functioning of human health (Agagaw*et al.,* 2021). It helps to maintain the stable equilibrium of water; excess amounts of magnesium, however, slowly react with other minerals (Zhu et al., 2022; Muthusamy, *et al.,* 2023). Natural sources such as the weathering of parent rock and ion exchange are significant sources of magnesium in groundwater.

Iron:The concentration of iron in this study varied from 0.102 to 0.96, with a mean value of 0.814667mg/l. The observed average value falls within the allowable range recommended by WHO and NSDWQ. These findings slightly coincide with Abdulsalam *et al.* (2019). Although iron in water has less effect on human health, higher iron concentration may cause Diabetes, hemochromatosis, stomach problems, nausea, and vomiting, as reported by Agrawal *et al.* (2021).

Copper is also characterized as unwanted heavy metals in drinking water and can infiltrate the water system. The concentration of copper in the groundwater sample ranged from 0.02 to 0.271, and a mean value of 0.129833 was observed. This value is within the acceptable limit set by WHO for human consumption. The lower value of copper obtained in this study is in concurrence with the values reported by Abdulsalam *et al.* (2019). Thus, copper might have been removed by precipitation and complexation processes before getting to the groundwater (Folorunsho*et al.,* 2022).

Manganese:Observed manganese concentration ranges from 0.022 to 0.5, with a mean value of 0.217 mg/l. This value falls within WHO stipulated limit for drinking water. The low concentration of Mn may be attributed to the less dissolution of Mn from the surface onto the groundwater. It may also be attributed to nonbiodegradable wastes, which might have inhibited solid waste biodegradation, as Folorunsho et al. (2022) reported.

1.10 Status pollution using Metal Index (MI)

Table 8 indicates severe groundwater contamination by heavy metals, including lead, cadmium, chromium, magnesium, iron, and copper. Most samples were deemed unsafe. The overall MPI of all studied boreholes exceeded Class IV (Caerio et al., 2005)., indicating a high level of contamination. These findings highlight the urgent need to reduce heavy metal levels in groundwater.

1.11 CONCLUSION

It is concluded that the spatial patterns of water demand characteristics for the entire area shows that thetotal household water demand is 553,640 lpd, as against the total water supply of 321,423lpd, leaving a daily deficit of 232,217 Lpd, Major source include 28.43%, 20,77 and 20.27 representing; Borehole, Hand pump and Hand dug well respectively. While watersuitability for drinkingrevealed that Zn, Fe, Cu, and Mn fall within the acceptable limit set by WHO Pb, Cd, Cr, and Mg exceeded the permissible limits recommended by WHO. The MPI reveals the groundwater resource is seriously affected since the obtained values are greater than 6.0. This study gives an idea of the gap between the demand and supply of suitable water in the study area and can be utilized by governmental organizations and other organizations to create a thorough plan to lower the amount of heavy metals intake via the polluted water. It was also recommended that government may work with NGOs involved in WASH to ensure that all households, regardless of location, can access potable water.

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