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Review Article

Status of Water Used for Drinking and Irrigation in Kano: A Critical Review on Physicochemical and Heavy Metals Concentration

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Abstract

Water is one of the most important natural sources for the sustenance of all living organisms. The importance of water to human's ranges from domestic, industrial and also irrigational activities. The quality of water is affected by human activities as a result of urbanization, population growth, industrial production, climate change and other factors. Several attempts have been made by researchers in order to ascertain the sources of pollution of water in Kano state. This review provides a clear picture of various water analysis carried out by some researchers from different locations in the state. The water status of rivers, dams, ground water and sachet water used in Kano were presented in this paper. Based on the data considered in this paper, revealed that parameters in sachets and ground water consumed in Kano are within the WHO recommended standards for potable water and ensures the suitability of the water for human consumption. Industrial effluents activities contributed immensely in making the river water sources unfit for human and irrigation purposes. This review recommended that, government should sanction any industry that failed to adhere to environmental regulatory policies. Also, government and non-governmental organization should educate the communities on proper disposal of wastes. Phytoremediation should be use for the removal of pollutants from water and soil especially heavy metals.

Keywords: Challawa; Heavy metals; Physicochemical; Water

Introduction

Water is one of the most important and abundant compounds of the ecosystem [1,2,3]. It is the most vital element among the natural resources [4,5,6,7], and is critical for the survival of all living organisms including human, food production, and economic development. Also, Saeed and Mahmoud [8] reported that, importance of water in our day-to-day activities makes it necessary for thorough analysis to be conducted. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life [8-17]. According to Rabiu et al., [15], Abdulazeez [16] and Kalra et al., [17] the quality of water is of vital concern for the mankind since it is directly linked with human welfare or health. The quality of ground water [18], or surface water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region [19-24]. Usually, water quality is being described by its physical, chemical and biological properties [25-27]. According to Rahmanian et al., [28] the quality and suitability of water are determined by its taste, odor, colour, as well as the concentration of organic and inorganic matters. According to Nizel and Islam [5] the quality of water is affected by human activities and is declining due to the rise of urbanization, population growth, industrial production, climate change and other factors.

Sources of Pollution

Pollution is caused when a change in the physical, chemical, or biological condition of the environment harmfully affects the quality of human life, including other animals' lives and plants [29,30]. The major causes of water pollution in an environment are as a result of addition of biological or chemical substances, such as land surface washing [31]. Kanase et al., [32], Bhalme and Nagarnaik [33] understand that increase in industrialization, urbanization, agriculture activity and various human activities has increased the

pollution of surface water and ground water. To Khan et al., [34], increasing anti-environmental human activities and some natural processes the quality of water is decreasing continuously and is posing a great threat to all forms of life including humans. Polluted water is the major cause for the spread of many epidemics and some serious diseases like cholera, tuberculosis, typhoid, diarrhea among others [34]. Contaminants in the water can affect the water quality and consequently the human health. The potential sources of water contamination are geological conditions, industrial and agricultural activities, and water treatment plants as reported by [28]. Duressa et al [35] stated that the problems of contamination of urban water distribution system are diverse.

The major sources of water contaminants are mostly wasting from improper sanitation and agricultural and other activities that make their way to the water distribution networks as reported by [35,36]. Industrial wastewater originates from the wet nature of most large industries which require large quantities of water for processing and disposal of wastes. Most industries are therefore, located near water sources. The pollution potential of industrial wastewater is far greater than that of domestic wastewater [37]. Heavy metals are found naturally in the earth [38-40] and become concentrated as a result of human caused activities [41-43] reported that pollution of water with heavy metals is of grave consequence because both terrestrial and aquatic lives may be poisoned; it may cause disease due to the presence of some hazardous substance which may distort the water quality, add odours, and significantly hinder economic activities.

According to Masindi and Muedi [44]heavy metals can be found in traces in water sources and still be very toxic and impose serious health problems to humans and other ecosystems, because the toxicity level of a metal depends on factors such as the organisms which are exposed to it, its nature, its biological role and the period at which the organisms are exposed to the metal.Kano state is located in the northern part of Nigeria, where there is no any large water body or shared border with ocean [45]. Rapid population increase in the study area is as a result of natural increase i.e. birth rate and migration from rural areas into Kano metropolitan and other urban centers in the state from different rural areas within and outside the state which lead to high concentration of people in the Kano metropolitan, which in turn affect water the supply tremendously [46].

Some physico chemical analysis study of polluted water sample in Kano

Due to the significance of water to living organisms (both plants and animals), numerous studies had been carried out to ascertain the quality of drinking and agricultural water in different places all over the world including Kano state, mainly by determination of heavy metal, physical and chemical among other parameters present due to their impact on human health.

Surface water

Most of the rivers in the urban areas of the developing countries are the ends of effluents discharged from the industries [47]. Rivers serve as a source of water for human consumption as well as irrigation purposes. Due to the above-mentioned significance, it has become essential for the regular monitoring of the important parameters of the water. The following analysis were reported.

River Challawa: Challawa River is located in Challawa industrial estate (11°45′42N, longitude 8°46′17E) in Kumbotso local Government area. The River is one of the receiving rivers of effluents from Challawa industrial estate. The industries in the Challawa industrial estate range from tanneries and textile to foods and packaging industries [48-50] conducted research on river Challawa for the purpose of determining the concentration of some physicochemical parameters and heavy metals. The results obtained from the study revealed that, all the physicochemical parameters determined: total solids, total suspended solids, total dissolved solids, temperature, pH, chloride, sulphate, phosphate with exception of dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, and electrical conductivity are within the recommended standard limits for these content in drinking water. The results obtained from this study also indicates the pollution tendencies of the surface waters of river Challawa, attributable to high levels of Pb, Cr, and Cd recorded. Akan et al., (2009) in another study on river Challawa investigated the impact of tannery and textile effluents.

The finding of their study reveals that the concentrations of heavy metals in the water and sediment samples were higher than the WHO guideline values for the protection of aquatic life. Also, the concentrations of BOD, COD, and total organic carbon (TOC) were higher than the WHO limits for the protection of fish and other aquatic life. Sarauta and Colleague [51] assessed the presence of PCBs and PAHs in River Challawa and compared the concentrations of the pollutants with the acceptable limit set by Nigerian Standard and other international regulatory agencies. 26 samples of water were considered in the analysis. The result shows that Polychlorinated biphenyls were not detected but polycyclic aromatic hydrocarbons were detected in all the samples analyzed using GCMS. The total concentrations of PAHs in the water samples range between 0.001 to 0.087mg/l. The results obtained revealed that most of the pollutants present in water were at significantly very high levels especially at Zamawa village situated very close to Challawa industrial estate - the major sources of effluent discharge point, making the drinking water around area is not fit for consumption. The industrial activities had impact on Challawa River basin and its environment as reported.

River Jakara and Minjibir: The work of Akan et al., (2008) on water samples from river Jakara reported the levels of pH, temperature, conductivity, nitrate, nitrite, sulphate, TSS, TDS, phosphate, BOD, COD and DO were higher than the maximum

permissible limit sets by Federal environmental protection agencies (FEPA). Also reported the concentrations of metals in the wastewater and vegetables samples to be higher than the maximum contaminant limit sets by World Health Organization (WHO). Dike et al., [52] in their study in water samples from river Jakara detected high values of BOD, DO, SS, and chloride and reported the unsuitability of the river for irrigation purposes. In another study, Mustapha et al., [53] analyzed the physicochemical parameters of 27 samples from the riverine network of the upper Jakara River. Parameters like pH, temperature, conductivity, TDS, turbidity, salinity, BOD, COD, ammonia, TSS, SS, Cr, Cd and Pb were studied and compared with WHO standard. Yahaya et al., [54] carried out a study to determine the physical and chemical parameters of water collected from different points of river Minjibir. The EC, concentration of chloride, sodium, calcium, magnesium, TDS, sodium adsorption rate (SAR), and sulphate recorded in the water samples lies in the impermissible limit sets by WHO and Food and Agricultural Organization (FAO). While the concentrations of carbonate, bicarbonate, nitrate and boron are unsuitable for irrigation purposes as recommended by WHO and FAO.

River Tatsawarki: Bichi and Bello [55] investigated the physicochemical parameters as well as heavy metals concentrations of water samples from Tatsawarki river and concluded that the heavy metal in the water is very high and unfit for any purpose as the metal were found to be higher than the FAO guideline value with exception of Fe and Pb which were found to be below the FAO guideline values. Also, the physical and chemical parameters investigated reveals higher levels of TDS, SS, EC, turbidity, magnesium and chlorides than the WHO guideline values in both the irrigation water and the control site. Shawai and Co-authors [56,57,58] evaluated the concentration of some physicochemical parameters, heavy metals and E. coli in the samples collected from the riverine network of River Tatsawarki (Along AKTH/ Dental clinic, Zaria road) and compared with maximum allowable concentration (MAC) of WHO/NSDWQ Standards. Levels of various physicochemical, concentration of some heavy metals and presence of E. coli were determined using standard analytical methods. The results indicated that all the parameters analyzed are within the maximum permissible limits (MPL) recommended, with exception of alkalinity and Total hardness (TH) level at all the sampling station and only IG sampling point shows turbidity level below 5NTU. Also, the presence of E. coli was detected at all the sampling points. The work concluded the suitability of the water for irrigation purposes.

Watari and Tiga Dam: Watari Dam is situated 2 km from Bagwai town and 8km south west of Bichi, Kano, Nigeria. It has 1,959 hectares surface area with active storage capacity of 92.74 million litres [59,60]. The dam is located between latitude 12°9'24"N and 8°8'12"E with two distinct seasons (wet and dry). The rainy season which last from May to October and the dry season last from November to April. The mean annual temperature is between 16 – 410Cand the mean annual rainfall ranges from 700 – 813mm [15]. The study of Adamu and Ahmed [59], evaluated the physicochemical composition of Watari Dam for a period of ten months. The result showed monthly variations, where pH, temperature and Electrical conductivity means monthly values ranges between 6.1 – 8.0, 25 – 31oC, and 61.0 – 77.0µohm/cm respectively. Dissolve oxygen (DO), dissolve solid (DS) and biological oxygen demand (BOD) mean monthly values ranged between 2.5 – 3.9, 33 - 49 and 2.0 – 4.1 respectively. Suspended solid (SS) and nitrate means values ranges between 2.2 – 5.8 and 20.4 – 27.0 respectively. Rabiu and co-authors [15] investigated some physicochemical parameters of Watari Dam for a period of ten months.

Four sampling point were considered in this investigation. Mean range of parameters studied were temperature (21.5 – 29.5 °C), pH (7.3 – 8.9), DO (7.4 – 8.4mg/L), BOD (2.6 – 3.9mg/L), turbidity (0.10 – 0.25 m), electrical conductivity (156 – 245µS/ cm), TDS (167 - 389mg/L), phosphate (0.5- 2.9mg/L) and nitrate (13.5 – 23.2mg/L). The result showed some degree of variations between the two seasons in which total dissolved solids, electrical conductivity, turbidity and nitrate recorded significant difference between wet and dry season ($P<0.05$) while no significant difference observed in DO, BOD, phosphate, temperature and pH. The phosphate concentration of 13.5 – 23.2mg/L and nitrate concentration of 0.5mg/l to 2.89mg/L raised concern on accumulation of these elements that can posed threat of pollution to the dam thus indicating anthropogenic influence. Waziri et al., [61,62] investigated the levels and seasonal variations of some physicochemical properties, heavy metals and mineral in water, sediments and fish samples from Tiga dam. Significant differences in heavy metal concentrations were recorded between seasons but, variations within season were statistically insignificant. The result indicated that the Tiga dam water and its aquatic lives are safe for human consumption, irrigation system, domestic and industrial uses.

Tap water

Water, which is treated by different Municipal bodies, meets all drinking water quality standards at treatment plant and at the point where the water enters the distribution system. Water quality deteriorates in distribution networks and during collection, storage so it becomes obligatory to monitor water quality at each stage [63]. Zakari et al. [64] assessed the changes in the physical and chemical properties of piped-borne water supplied in Kano metropolis from two treatment plants (Challawa and Tamburawa plants), along the distribution lines to the various points of use in Kano metropolis. The research work emphasized on parameters such as pH, alkalinity, conductivity, turbidity, total dissolved solids, total suspended solids, sulphates, chlorides, nitrates, nitrites, sodium, potassium, calcium, magnesium, lead, cadmium, chromium, manganese, iron, nickel, zinc and copper. All the physical and chemical parameters analyzed in the water samples were all within the World Health Organization (WHO) and Standards Organization of Nigeria (SON) limits, hence making piped-borne water in Kano metropolis safe for drinking

and other purposes. Audu and Idowu [65] analyzed a total of 92 water samples comprising of raw (from plants) and treated (from the plants and taps) were collected for the period of 2 years and analyzed using standard analytical techniques of the parameters analyzed, turbidity and total solids were found to be high in some sampling point, while pH values were generally acidic.

The highest values of Fe, Cu and Mn were recorded along the older distribution channel of Challawa. The levels of Pb and Cr were generally high in both routes which are also observed in the raw water used at the two treatments plants. The results obtained from heavy metal concentrations fell within the maximum allowable limit set by the WHO for portable water except in the cases of Pb and Cr.

Ground water

Natural groundwater is usually of good quality, but this can deteriorate due to inadequate source protection and poor resource management [66]. It's contamination may be due to improper dwelling of well and waste disposal [67]. Dohare et al., [68] reported that groundwater is used for domestic and industrial water supply and also for irrigation purposes in all over the world. Bernard and Ayeni [69] ascertained the quality of ground water in Bichi local government area and compared the results with the accepted limits of World Health Organization (WHO) and Standard Organization of Nigeria (SON). The samples taken from twenty different locations revealed that the study area has a mean of Turbidity 2.0 NTU, Colour 2.5 TCU, Temp. 25°C, pH 6.8, Total Alkalinity 85.0 mg/l, Total Hardness 71.83 mg/l, and others are: Calcium 25.24 mg/l, Magnesium 2.19mg/l, Iron 0.05, Chloride 7.89mg/l, Nitrate 0.79 mg/l, Total dissolved solid 81.0 mg/l, and Conductivity 135S/cm. Based on the results obtained, the ground water satisfied the safety limit for various purposes including; domestic, agricultural, and industrial. The study of Adamu et al., [70] investigated the quality of groundwater for safe drinking, by testing parameters like pH, Electrical conductivity (EC) and Ionic concentration of Calcium (Ca), Magnesium (Mg), Iron (Fe), Chlorine (Cl), Nitrate (NO_3), Ammonium Nitrate (NH3N), Sulphate (II)oxide (SO42-), Silicon oxide (SiO2), Fluoride (F-), Carbon dioxide (CO2) and TDS from various Precambrian Basement Complex rocks in Kano State.

The parameters analyzed, shows that the groundwater from the study area is fit for human consumption. Sa'eed and Amira [71] assessed some physicochemical parameters of borehole water used for drinking and domestic purposes in Nasarawa Local government Area. pH, Alkalinity, Conductivity, Total dissolved solids (TDS), Total hardness, Permanent hardness, temporary hardness were among the parameters analyzed. The results indicated that pH, conductivity and total dissolved solids were within the acceptable range recommended by World Health Organization. (WHO), while Alkalinity, Total hardness, Permanent hardness, Temporary hardness, Calcium hardness and Magnesium hardness were all above the safe limit recommended by WHO. Saeed and Mahmoud [8] evaluated the physical and chemical parameters as well as heavy metals concentrations of drinking water used in Fagge local government area in Kano. The results indicated that, all the physicochemical and heavy metals are within the acceptable limits set by WHO except for pH level at Weather head and lead level in Kwarin gogau sampling sites respectively.

A research was undertaken by Nahannu et al., [72]; Shawai et al., [73] in Gezawa, Nigeria to have an idea of the extent of ground water pollution due to contamination with industrial effluents as well as sewage wastes. Shawai et al., [60] conducted water quality assessment in Unguwa Uku, Kano metropolitan Nigeria in October 2016 and reported that, agricultural activities as well as effluents from domestic and abattoir are the major causes of water pollution within the study area. The research work carried out by Bataiya et al., [74] to investigate the contamination level of groundwater by determination of physical and chemical properties, revealed that the groundwater quality is deteriorated due to higher concentration of EC TDS and hardness as compared to WHO standards. As the result indicated all the parameters are within the recommended levels set by WHO and NSDWQ except for conductivities at all the samples site, and magnesium at D_1, D_2, and D_3. The work of Hassan and co-workers [75] analyzed pH, temperature, TDS, TSS, SS, EC, Alkalinity, Mg^{2+}, Ca^{2+}, colour, free CO_2, turbidity, TH and Chloride. The results indicated that all the parameters analyzed are within the permissible limits recommended by World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) with exception of turbidity level at YS sampling station, Mg2+ concentration at DS and YS sampling point and total hardness from sampling point DS.

Physicochemical and bacteriological analyses were carried out on well water samples from eight selected locations within the industrial area of Kano Metropolis including Bompai, Sharada, Challawa and Jaba [19]. The physicochemical parameters monitored includes pH, electrical conductivity, TDS, DO, BOD, Turbidity, chloride, nitrate, phosphate, zinc, iron, lead, manganese and chromium. The result revealed concluded that seven out of the eight (8) wells assessed were not fit for consumption. Shawai et al., [56] determine the physicochemical parameters of water samples collected from Sa'adatu Rimi College of Education, Kumbotso Kano and compared with the standards recommended by WHO and NSDWQ. Four samples were collected from different locations within the college premises for the analysis. The analyzed parameters are within the permissible limits recommended by WHO and NSDWQ with exception of turbidity level at A sampling station, pH concentration at B, C, and D sampling point and nitrite concentrations at C and D sampling point. The results also showed that, the concentration of total hardness was slightly above. The work suggested that, levels of microbial contaminant, inorganic constituents and other parameters not considered in the research should be assess in future study.

Sachet Water

Water can be described as potable, when it complies with certain physical, chemical and microbiological standards, which are designed to ensure that the water is potable and safe for drinking [76]. Sachet/packaged/potable water is the water that is free from disease producing microorganisms and chemical substances that are dangerous to health [77-85]. Packaged water is raw water purified to remove physical, chemical and microbial contaminants and packaged into labeled containers [86,87]. The production and sell of sachet/package water or pure water is one of the common businesses in Kano Nigeria, so the need to assess the status become necessary. In Kano, sachet water is main water used for drinking especially in metropolitan area. Analysis were carried out to assess the quality of this water, including the following:

Uwah and co-workers [88] concluded that the physicochemical and bacteriological parameters in sachets water consumed in Kano metropolis conformed to the WHO recommended standards for potable water and that the consumption of the sachets water may not pose health hazards to the consumers at the time of the study. 25 brands of sachet water packaged within Kano metropolis was evaluated by [89]. Concentrations of Pb, Fe, Zn and Cu were determined using atomic absorption spectrophotometer (AAS). Conductivity, pH, Total dissolved solids and total hardness were determined using suitable methods of analysis. The concentrations of the metals, conductivity, TDS and total hardness were below the allowable limits set by standard organization of Nigeria (SON) and WHO. However, pH concentration was found to be high in some samples analyzed. Sheshe and Magashi [90] analysed fifty (50) brands of sachet water produced from borehole and tap water in five local government areas of Kano metropolitan. Chemical parameters such as conductivity, total hardness, nitrate and nitrite, total dissolved solids, fluoride, and heavy metals such as Manganese (Mn), Arsenic (As), Zinc (Zn), Copper (Cu), and Lead (Pb) conformed to the requirements of WHO and NIS standards.

The findings revealed that the physicochemical parameters tested in all the sachet water samples were within the permissible limits stipulated by the drinking water standards, hence on this basis the water is considered fit for drinking.

Conclusion

The effects of water pollution are not only devastating to people but also to animals, plants, and soil. Polluted water is unsuitable for drinking, recreation, agriculture, and industrial activities. The present review paper undertaken to account to bring an acute awareness among the people about the quality of water in Kano state. Based on the previous research, it can be concluded that the parameters in sachets and ground water consumed in Kano are within the WHO recommended standards for potable water and ensures the suitability of the water for human consumption. In case of river and dams' water, industrial effluents contributed immensely in making the river water sources unfit for human and irrigation purposes.

Recommendations

The following recommendations were made:

1) The agencies concerned such as FME, KSME, NAFDAC, NASREA, SON among others, should strengthen their legislation against indiscriminate and improper waste disposal along waterways.

2) Hand dug wells and boreholes should be drilled some meters far away from any source of contaminations or pollution.

3) Government should sanction any industry that failed to adhere to environmental regulatory policies.

4) Also, government and non-governmental organization should educate the communities on proper disposal of wastes.

5) Phytoremediation should be use for the removal of pollutants from water and soil especially heavy metals.

6) There is need for regular water quality monitoring which should include trace metal levels, nutrients and microbiological analysis.

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