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Determination of the Physicochemical and Bacteriological Parameters of Water Used for Irrigation in Kano, Nigeria

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Abstract: *Irrigation is the artificial application of water to the soil for agricultural purposes. In most cases, existence of dry season is what gives birth or necessitates irrigation. Irrigation water from three sources (Challawa river, Jakara river, and Thomas dam at Dambatta) within and around Kano metropolis were analysed. The physicochemical parameters examined and their concentrations for the three itemised sources respectively include: PH (1.9, 6.9, and 7.2); Electrical Conductivity in µS/cm (8240, 1020, and 430); Magnesium in mg/l (49.27, 68.55, and 41.23); Sodium in mg/l (40.78, 28.11, and 36.55); Total Hardness in mg/l (1200, 450, and 200); Copper in mg/l (0.51, 0.08, and 0.02); Arsenic in mg/l (0.26, 0.04, and 0.01); Zinc in mg/l (2.94, 4.57, and 0.58); Lead in mg/l (0.699, 0.276, and 0.013) and Total Dissolved Solids in mg/l (4055, 2433, and 1069). While the bacteriological parameters examined were: E. coli; Salmonella; Shigella, Vibrio Cholerae; Pseudomonas and Total Coliform Bactria (TCB). All the irrigation water sources have demonstrated an alarming presence of all the bacterial contaminants with the exception of Challawa whose all samples showed negative for Shigella only. Total Coliform Bacteria (179.63, 1026.55, and 256.12/ml) also far exceeded the provided guideline of 1000/100ml. open defecation and poor management of the large volume of waste produced (including raw sewage) due to excessive domestic and commercial activities that also gets into the water sources may have caused this. The water can therefore be said to be contaminated making it unsuitable for irrigation purpose. On the physicochemical parameters, many of them like Electrical Conductivity, Zinc, and Total Dissolved Solids were found to be well above the maximum allowable limits in at least two of the three sources. Even though, Sodium, Total Hardness and Lead were found to be within acceptable limits in all the three sources, but the presence of concentrations of the other parameters in excess of allowable limits calls for serious concern that makes the water sources unsuitable for irrigation. Serious measures must be put in place to curtail the sources of this contamination before making more efforts again to neutralise the one already in there*

Keywords: Irrigation

I. INTRODUCTION

Water is only second to air in importance. Its availability sustains life and all of what life needs for a healthy survival [1].Without water, there will be no food production, economic development will be halted and there will be emergence of diseases [2]. Artificial application of water to soil for agricultural purposes is called irrigation [3]. It is water that makes the soil tillable and suitable for agricultural use [4]. In Nigeria, development of water resources for irrigation use is traced back to the pre-civilisation era [5]. However, not much was formerly done to harmonise the system for an improved efficiency until in the 1970s when FAO and the United States Bureau of Reclamation conducted a research which produced three pioneer irrigation schemes namely: The Bakolori Irrigation Scheme, the Kano River Irrigation

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Scheme and the Chad Basin Irrigation Scheme. The available sources of water are rivers, streams, lakes, ponds, rain water, and groundwater such as spring water, well water, boreholes etc. Water pollution results in the contamination of the environment giving birth to an unsustainable utilisation of the available resources, thereby leading to concerns of global dimension [6]. There is an observed increase in the demand for water resources primarily due to rapid urbanisation, population growth, and changes in the global climatic conditions. The increased pressure on this resource leads to the possibility of pollution of irrigation water with harmful substances and other unhealthy practices [6]. While ascertaining the availability of water for irrigation use, both quantity and quality must be taken into account. Unfortunately, the quality aspect is often neglected [7]. But health concerns of global dimension as a result of the use of water of poor quality for irrigating crops, particularly those eaten raw have often been reported[4]. Though [8] reported that the above may be due to plentiful supply of irrigation water,however, [6] reported that irrigation agriculture suffers water insufficiency in Kano, particularly during dry season, reason such farmers resort to the use of industrially contaminated water sources for irrigation. River Jakara as one of the sources where samples were drawn from, has traversed the city of Kano thereby possibly getting contaminated with domestic wastewater, solid waste due to high population density and intense commercial activities, and open defecation. Challawa is an industrial area. It is an area dedicated for industries. But irrigation agriculture is also being practiced using river challawa as the source of water for that purpose. Some of the industries available at challawa area include pharmaceutical and tannery industries that use harmful chemical substances in their production processes. On the other hand, there is no certainty whether effluents from such industries are sufficiently treated before being discharged into the available river (river challawa) or not. At Thomas dam (Dambatta), run off comes largely from farmlands and other open places upstream. The tendency of having variety of dissolved salts, which affect the quality of irrigation water from that source is also high[7]. There is also the possibility of faecal contamination due to open defecation by workers and vegetable market close by. The above quality concerns were the reasons that necessitate this research work, primarily conducted to investigate the safety of the crops produced with water obtained from the identified sources, particularly those eaten in raw form such as carrot, lettuce etc.

II. MATERIALS AND METHODS

2.1 Study Area

Kano, which is named the most populous city in Nigeria is located between latitude of 12˚00ˈN and longitude 8˚31ˈE. Of the three sampling points, river Jakara passed through the ancient city of Kano, where the population density is about the highest, raising the possibility of irrigation water contamination with domestic wastewater, solid waste and open defecation. River Challawa which is located in an area with the presence of many industries like tannery, pharmaceuticals, textile, fertilizer etc. also stands the chance of being contaminated as a result of possible discharge into the water, untreated wastewater from such chemical industries. Thomas dam at Dambatta also receives runoff from farmlands and other areas with chances of contamination.

2.2 Sample Collection and Preparation

The entire water sampling activities were conducted between September 2024 and January 2025. In order to ensure that representative samples were used throughout the research work, each sampling source was divided into three: upstream, downstream and midstream. Samples were taken from each of this points and relevant tests conducted on them. Laboratory test were conducted at Hussaini Adamu Federal Polytechnic, Kazaure (Science and Laboratory Technology Department) and the Centre for Dryland Agriculture of the Bayero University, Kano. Tests were conducted in conformity with the APHA standard methods for the examination of water and wastewater. Also, the sample collection was done in 750ml airtight plastic bottles and under ice conditions to avoid further contamination before the tests were conducted.

2.3: Materials and Equipments

Some of the materials and equipments used in carrying out the test are: for the storage of the samples to avoid further contamination, ice blocks, cooler, labels and plastic bottles were used. also, some of the measuring instruments used include: PH meter, conductivity meter, Atomic absorption spectrometer, Flame photometer, and materials for culture techniques for bacteriological analysis. For good and reliable results, glass wares such as pipettes, beakers, test tubes,

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petri-dishes flasks etc., were properly sterilized. They were first of all, washed thoroughly with water and detergent, then with clean water and finally with distilled water. All the dust in them were scrubbed and washed clean before being used. also, the glass wares were sterilized at standard temperature and pressure and then oven dried at a temperature of 60*C before the test were conducted with them.

2.4 Bacteriological Analysis

Bacteriological parameters determined and analysed from the irrigation water include: Shigella, Salmonella, E. coli, Vibrio Cholerae, and Pseudomonas. Experimentation to determine the bacterial presence in the irrigation water was conducted at Hussaini Adamu Federal Polytechnic, Kazaure (Nigeria) in the Laboratories of the department of Science Laboratory Technology. The procedure includes preparing serial dilutions of the sample in an already sterilised water and then cultivating them on nutrient agar and in a sealed but incubated container (dish). The first set of plates were incubated at 22*C for a complete one day while the second one at 37*C for another 24 hours. However, the nutrient is prepared to contain some reagents that will check the growth of other organisms for the target one to be easily identified.

2.5: Physico-Chemical Parameters

The other component of the analysis involved Physico-chemical parameters. The parameters investigated under this part include: PH, Electrical Conductivity (EC), Total Hardness, Carbon Hardness, Magnesium Hardness, Total Dissolved Solids (TDS), Arsenic, Copper, Zinc, Lead, Iron, and chlorides. For the determination of Zinc, Arsenic, copper and Iron, Atomic Absorption Spectrometer (AAS) was used. this method involves atomising the sample for elemental analysis. It detects the presence as well as the concentration of a particular target element through their wavelengths and its possible absorption on a spectrum of light. All the test conducted on the samples to determine the Physico-chemical parameters were based on standards provided by (APHA, 2005)[3][9]

III. RESULTS AND DISCUSSION

3.1 Escherichia coli (E. coli)

Lauryl Sulphate Broth (LSB) was the culture media used to detect the presence of E. coli in the various water samples. The samples were filtrated and then incubated in LSB supplemented with the substrate4-aminophenyl-d-galactopyranoside (4-APGal). As indicated on Fig. 3.1, samples from both Thomas dam and Jakara rivers indicated the presence of E. coli contamination. However, irrigation water samples from Challawa had returned 5 negative samples (to E. coli) out of 20 irrigation water samples while that of Thomas Dam had 3 samples out of 13 with negative results. Jakara had returned all of the tested samples positive.

3.2 Salmon**ella**

To determine the presence or absence of this parameter, Salmonella-Shigella (SS) agar was used. As presented in Fig. 3.2, this procedure has detected the presence of salmonella in all the water sources from which the samples were drawn. However, while all the samples from Jakara river were returned positive for Salmonella, 2 of the 20 samples from Challawa were negative. Also, 1 of the 13 samples from Thomas Dam was negative for Salmonella.

3.3 Shigella and Vibrio Cholerae

To determine the presence or absence of Shigella in the irrigation water, Salmonella-Shigella (SS) agar was also used. As presented in Fig. 3.3-1, this procedure has detected the presence of Shigella in Jakara irrigation water (14 positives and 2 negatives) and Thomas dam irrigation water (3 positives and 11 negatives). The samples drawn from the Challawa sampling site showed 15 negative and 5 positive results forShigella examination. On the other hand, Thiosulphate-citrate-bile salt (TCBS) agar was used to detect Vibrio Cholerae in the samples tested. It indicated yellowish but irregular pigment that is also rough and clearly visible. As indicated on Fig. 3.3-2, all the water sources contain Vibrio Cholerae (Challawa: all positives; Jakara: 13 positives and 2 negatives; Thomas Dam: 10 positives and 5 negatives).

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3.4 Pseudomonas

Here, pseudomonas F. Agar was used. This agar is capable of detecting pigment production by Pseudomonas species. In this case, Pseudomonas agar produced colonies that are fluorescent-yellow-green under ultraviolet light. All the tested samples indicated the presence of Pseudomonas except 5 sample from Dambatta irrigation water. Fig. 3.4 presented the composite bar chart for the results.

3.5 Total Coliform Bacteria

For this purpose, a series of Lauryl Lactose broth primary fermentation tubes were inoculated with granulated quantities of the sample to be tested. The results show that Jakara river has the highest MPN count of 1026.55/ml followed by Thomas Dam with 256.12/ml and then lastly, Challawa with 179.63/ml. The overall average is 487/ml. results are presented in Fig. 3.5

3.6 Results of Physico-chemical Analysis and Discussion

3.6.1 PH

PH of the tested irrigation water was measured by the use of a PH meter and was achieved at the sampling points before the samples were taken to the laboratory for further examination. The average PH ranges from 1.9 to 7.2. Challawa recorded an average PH of 1.9 (acidic), Jakara had an average PH of 6.9 (slightly acidic) while Thomas dam had 7.2 (slightly alkaline). Both Jakara and Thomas have their PH within limits of both FAO(Food and Agricultural Organisation) of 6.5-8.5 and FEPA (Federal Environmental Protection Agency) of 6-9, making them suitable for irrigation purposes. The observed low PH value associated with Challawa river may be as a result of possible wastewater discharge from industries like chemical producing factories, tannery, metal plating located in the vicinity. Tanning for example, involves the use of acids and acidic chemicals in some of their processes. Those chemicals are capable of lowering the PH of water if the industrial effluent gets into the river without passing through the necessary treatment processes.PH levels can be raised by adding alkaline substances that include calcium hydroxide, ammonium hydroxide etc. Fig. 3.6presents the results.

3.6.2 Electrical Conductivity (EC)

Electrical conductivity in irrigation water represents the concentration of dissolved salts in the water. It is a critical factor in determining the suitability of water for irrigation or otherwise. High value of Electrical Conductivity indicates that the soil is highly saline and therefore not suitable for irrigation purposes. This is because high salinity makes the soil highly solidified thereby lowering the permeability of the soil, which in turn prevents nutrients from reaching the root of crops [6]. Laboratory examination conducted on the irrigation water samples has revealed that Challawa river has an average Electrical Conductivity of 8240µS/cm. Jakara has 1020µS/cm while Thomas dam has 430µS/cm with an overall average of 3230µS/cm. This results indicate that EC for both Challawa and Jakara have exceeded the maximum allowable limit specified by both FEPA and WHO of 600µS/cm and 500µS/cm respectively making the water unsuitable for irrigation purposes. The above circumstances may be associated with some industrial and commercial activities that lead to high deposit of salts in the vicinities of Challawa and Jakara which Thomas dam doesn't have (reason for the low EC value for Thomas dam). Cultivation of soils with high salinity requires the use of costly farming implement which makes it not economical. But the salt content of the water can be controlled by mixing it with low salinity water or be treated using desalination techniques. Fig. 3.7 shows the results.

3.6.3 Magnesium Concentration

Pronounced concentration of Magnesium in irrigation water has some harmful consequences that include degrading the soil profiles leading to possible difficulty in the movement of nutrients through the soil to the roots of crops. This adversely affects crops' yield. High magnesium content compared to calcium in irrigation water also makes it difficult for the crop to absorb calcium as magnesium competes with it, thereby reducing the amount of nutrient available to the crop.

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In this research work, Magnesium was determined using a standard solution of Ethylene diamine tetra acetic acid (EDTA) through titration. Magnesium concentration was determine in the range of 41.23mg/l to 68.55mg/l with an overall average of 53.02mg/l. Challawa recorded an average of 49.27mg/l, Jakara river has an average of 68.55mg/l while Thomas dam was found to have 41.23mg/l. Going by the maximum allowable Magnesium limit prescribed by the Food and Agricultural Organisation (FAO) of 60mg/l [5], irrigation water from Jakara with 68.55mg/l is likely to negatively affect the crops growth, making it unsuitable for irrigation purpose. The results are shown in Fig. 3.8

3.6.4 Sodium Concentration in Irrigation water

The amount of sodium in the irrigation water tested was determined using flame photometer. Sodium was detected in the range of 28.11mg/l to 40.78mg/l with the overall average of 35.15mg/l. Challawa irrigation water has an average of 40.78mg/l, Jakara was found to have an average of 28.11mg/l while Thomas dam has 36.56mg/l. However, all the three values of sodium have fallen below the maximum allowable limit provided by FAO of 200mg/l. All the irrigation water sources are suitable for irrigation purpose given the above findings. Fig. 3.9presents the results.

3.6.5 Total Hardness in the Water Samples

To determine the total amount of hardness in the water samples collected from the chosen sources, EDTA method was used. Total hardness was determined in the range of 200mg/l to 1200mg/l with an overall average of 606.67mg/l. Challawa river recorded 1200mg/l of total hardness, Jakara recorded 450mg/l while Thomas dam recorded 200mg/l. Challawa has the highest value with Thomas dam having the lowest value. The maximum allowable value of 300mg/l [10] are exceeded by two of the three water sources. Water having low Hardness limits below 50mg/l may have to be supplemented with calcium and magnesium fertilizer for proper plant growth. While that with high total hardness (above 300mg/l) can create blockage of irrigation systems leading to possible damage of equipments and unwanted deposit on the plant too. The safe concentration is that recommended by [10] of 50mg/l to 150mg/l, named moderate range. It therefore indicated that only Thomas is suitable for irrigation in this regard. Fig. 3.10 presents the results.

3.6.6 Copper concentration in the samples

The concentration of copper in the tested irrigation water was ascertained using Atomic Spectrophotometer. Challawa has 0.51mg/l, Jakara recorded 0.08mg/l and Thomas Dam has 0.02mg/l. the overall average is 0.20mg/l, exceeding the copper limit provided by FAO of 0.1mg/l. However, only challawa river water had exceeded the recommended limit. Deficiency of copper in the human body may lead to cardiovascular disease and several other health issues [11]. All the irrigation water sources are suitable for irrigation in respect of copper concentration. The results are presented in Fig. 3.11

3.6.7 Arsenic

Samples of irrigation water from different sources were analysed for the presence of Arsenic. Also, atomic absorption spectrophotometer was used to achieve the desired results. Thomas dam has the least value of 0.01mg/l while Challawa irrigation water has the highest value of 0.26mg/l with an overall average value of 0.10mg/l. However, only Challawa with a value 0.26mg/l exceeded USEPA (United State Environmental Protection Agency) Guideline value of 0.1mg/l. High arsenic concentration in irrigation water can lead to land degradation thereby adversely affecting the yield of crops [12]. It therefore means that only Challawa source is unsuitable for irrigation purposes. Fig. 3.12 presents the results.

3.6.8 Zinc

By the use of Atomic Absorption Spectrophotometer, the concentration of zinc in irrigation water from the identified sources was detected. Highest value of 2.94mg/l was recorded in Challawa irrigation water while the least value of 0.58mg/l was detected in Thomas irrigation water. The overall average is 1.70mg/l. By the USEPA standard, only Challawa irrigation water has exceeded the guideline. Excess zinc in irrigation water can be toxic to plants. This is because it can lead to stunted growth of the crops thereby reducing yield. Severe cases can even lead to the death of the

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plant [4]. In respect of zinc concentration, only Challawa irrigation water source can be said to be unsuitable for irrigation purpose. Fig. 3.13 presents the results.

3.6.9 Lead

Concentration of lead in the irrigation water sources was obtained using Atomic Absorption Spectrophotometer. The highest lead concentration of 0.699 mg/l was found in Challawa irrigation water while least of 0.013mg/l was obtained from Thomas dam, Dambatta. The overall average is 0.33mg/l. Jakara irrigation water got 0.276mg/l. Excess lead in the human body leads to various diseases that include kidney failure, brain damage, and cancer. However, all of the water samples have got lead concentrations below both FAO and USEPA recommended limits of 5mg/l and 2mg/l respectively. This means that all the irrigation water sources are suitable in respect of lead concentration. Fig. 3.14 presents the results.

3.6.10 Total Dissolved Solids (TDS)

Gravimetric Analysis was used to obtain Total Dissolved Solids in the irrigation water. The filtered sample was evaporated to dryness while the remaining residue was measured as the mass of dissolved solids in the irrigation water. The highest value of 4055mg/l was obtained from Challawa irrigation water source. Thomas dam, Dambatta has the least value of 1069mg/l while Jakara has 2433mg/l with an overall average of 2519mg/l. Challawa and Jakara irrigation water have exceeded the allowable limit by WHO and FEPA of 2000mg/l. The value at Challawa may not be unconnected with the presence of many industries like the chemical manufacturing, tannery and textile industries that use dissolves substances. There is also irrigation activities and runoff from farmlands that introduce loads of dissolved substances into the water. One of the effects of excess TDS is that it decreases the amount of water that gets to the roots of plants by increasing osmotic pressure[6]. This in turn adversely affect growth, development, and yield of the crops. However, it can be avoided by choosing water sources with less TDS or resort to treatment before use.Here, only Thomas dam is suitable for irrigation purposes. Fig. 3.15 presents the results.

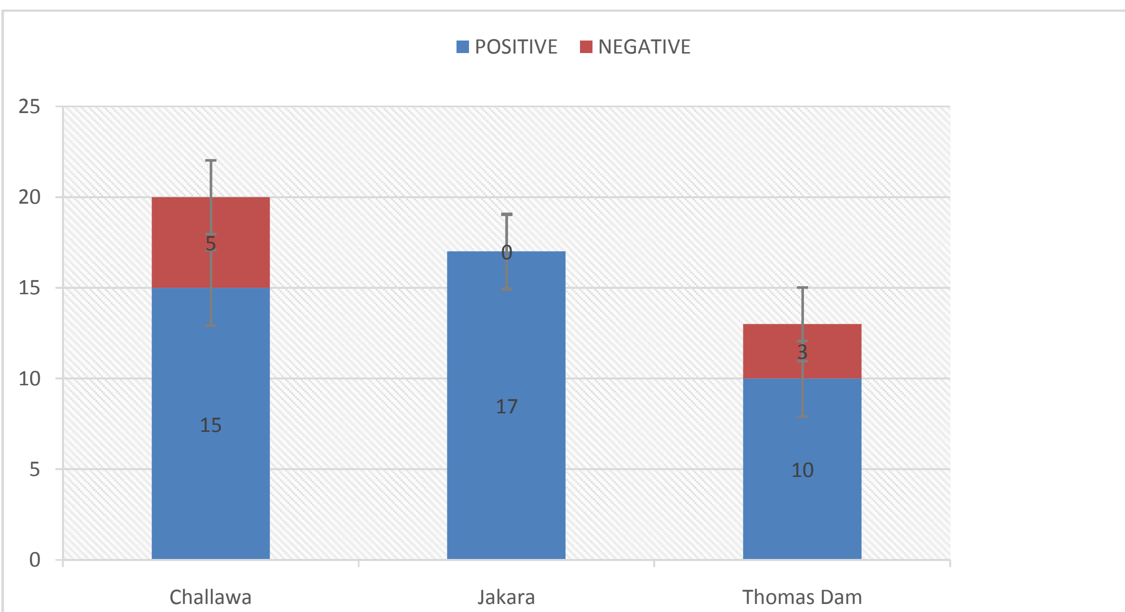

Fig. 3.1 E. coli Representation

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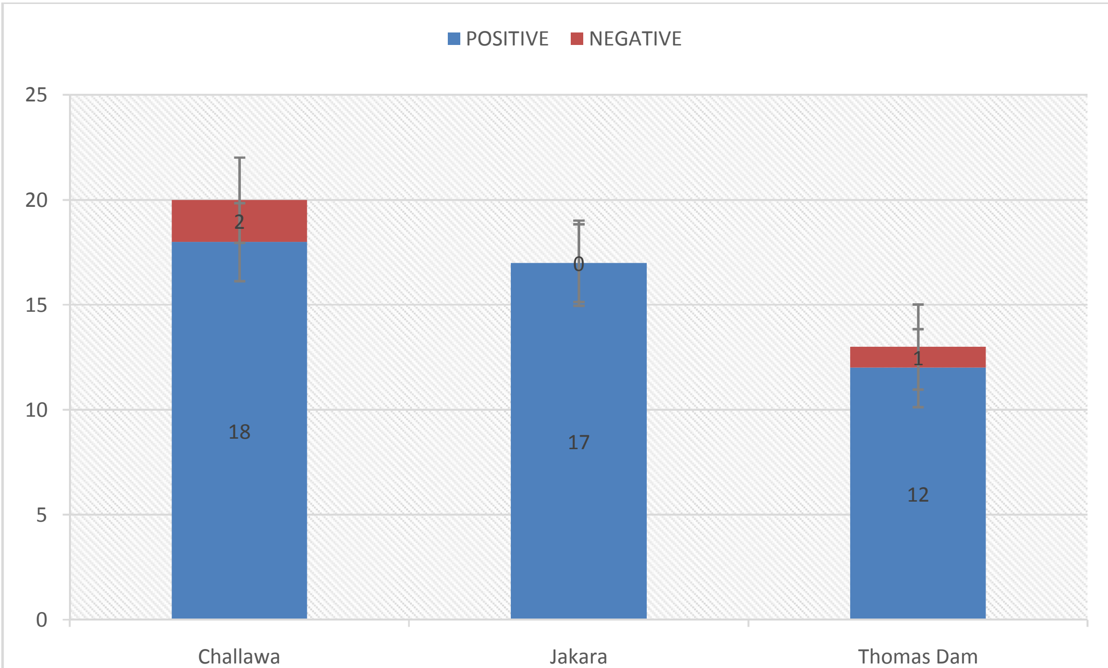

Fig. 3.2: Chart representation of Salmonella

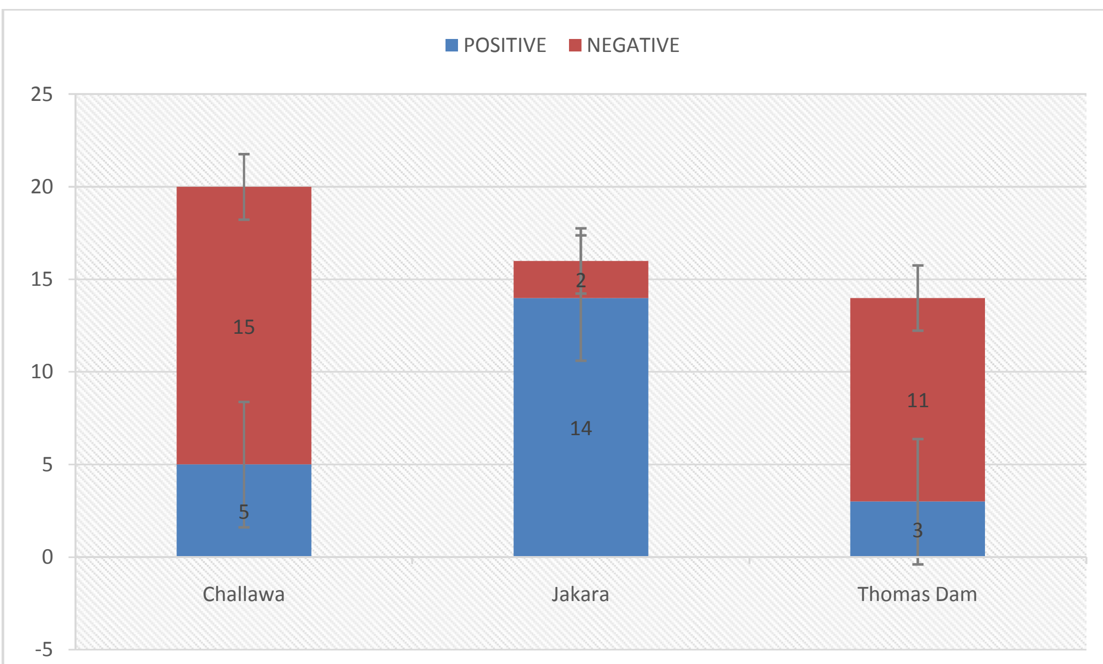

Fig. 3.3-1: Chart representation of Shigella

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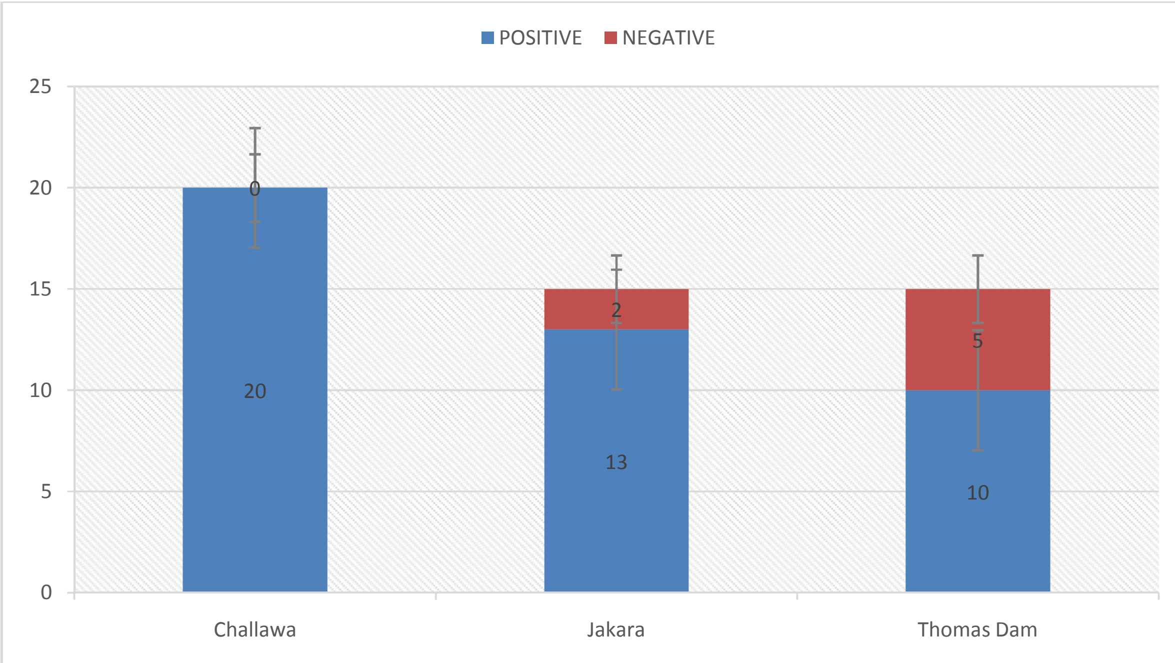

Fig. 3.3-2: Chart representation of Vibrio Bacteria in Irrigation water

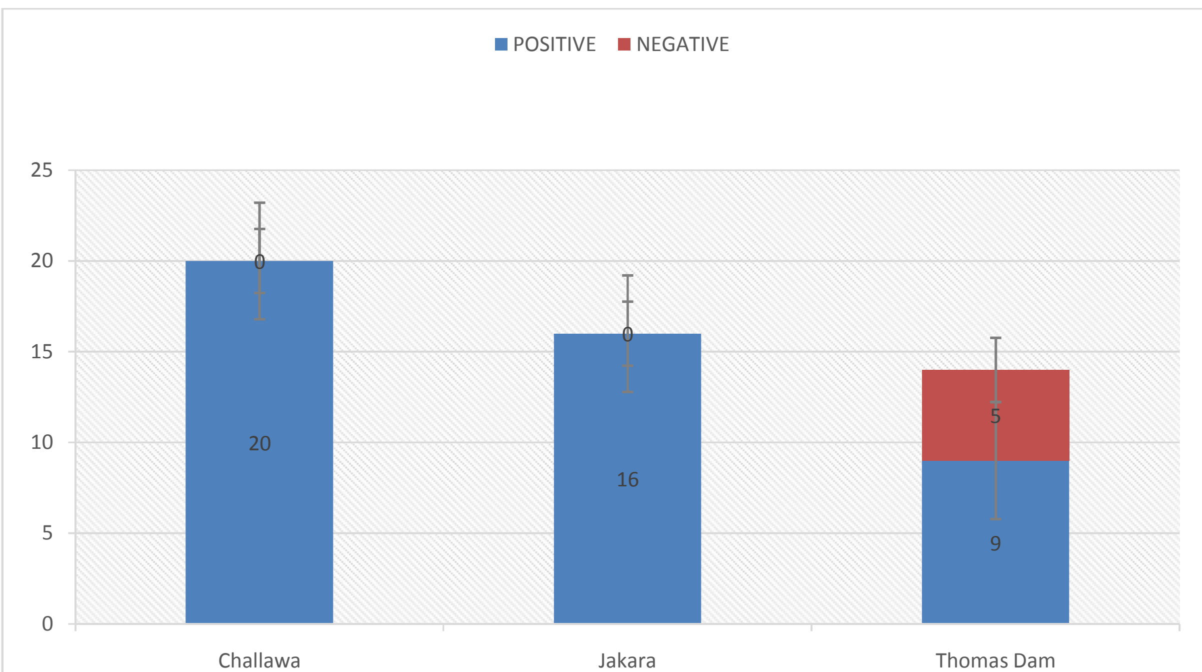

Fig. 3.4: Chart representation of Pseudomonas in Irrigation water

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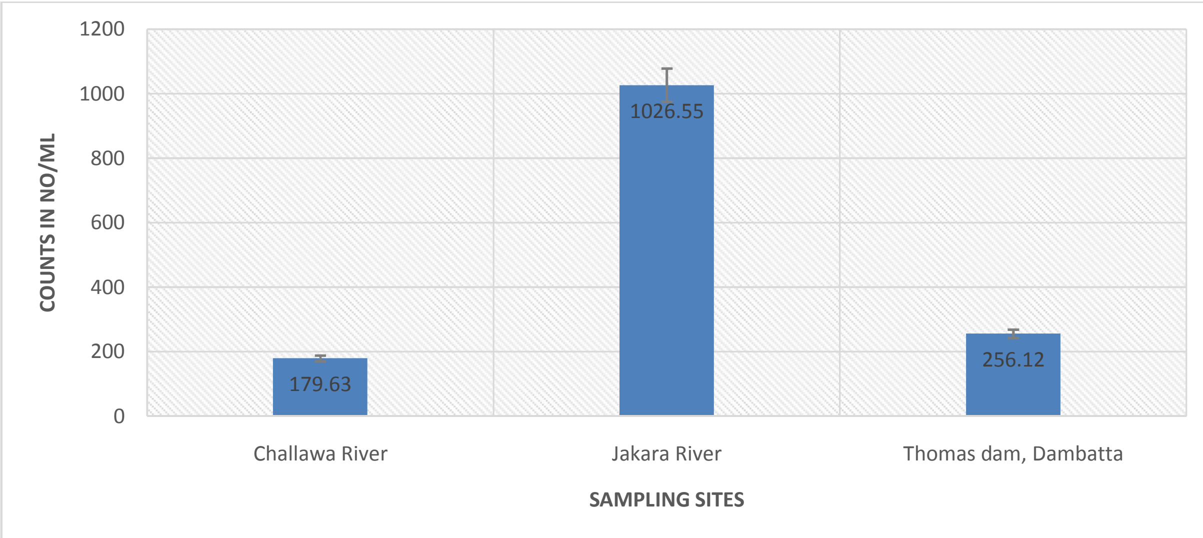

Fig. 3.5: Total Coliform Count in Number/ml

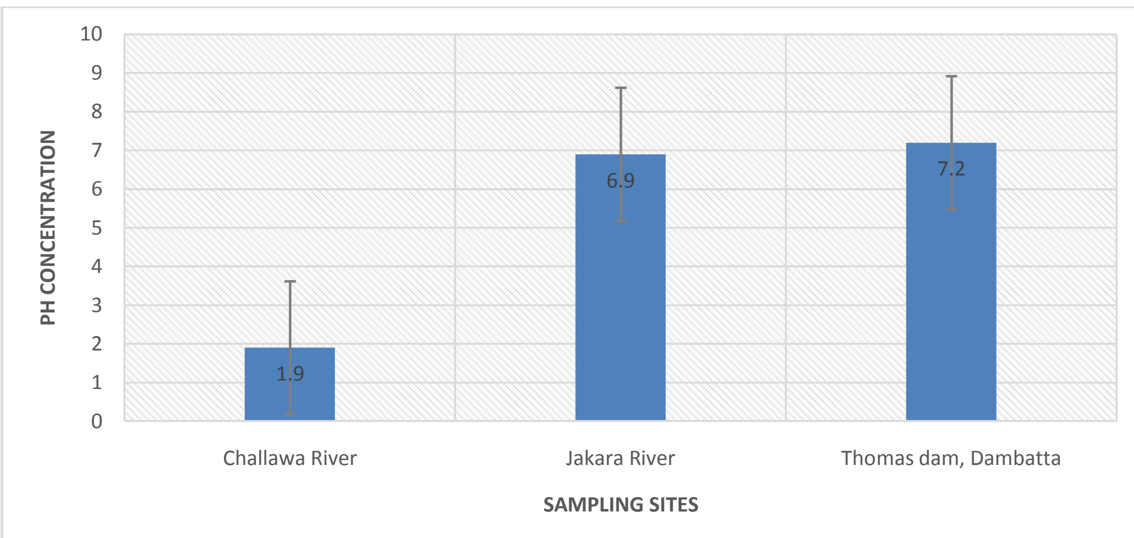

Fig. 3.6: Chart Representation of PH of Irrigation Water

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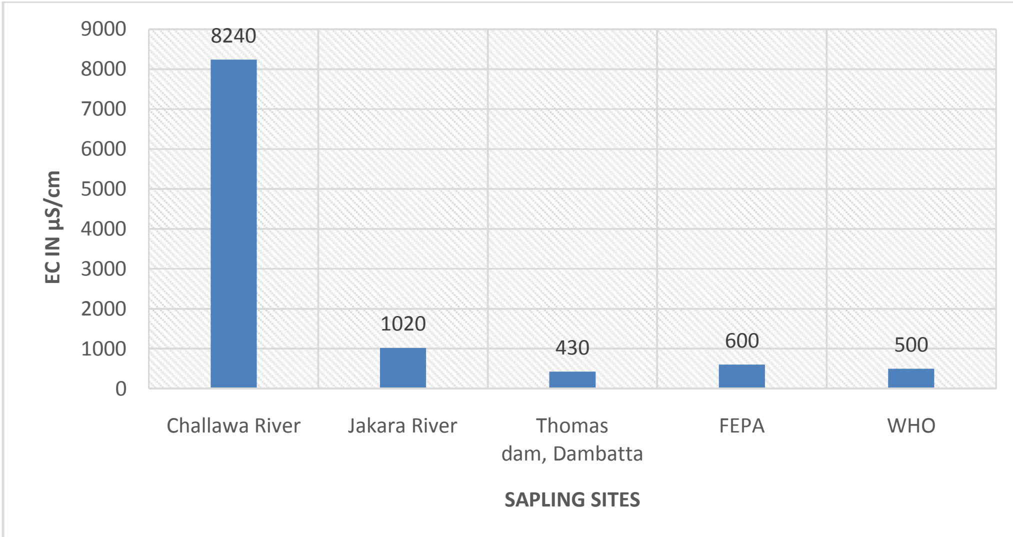

Fig. 3.7: Chart Representation Electrical Conductivity Relative to Standards

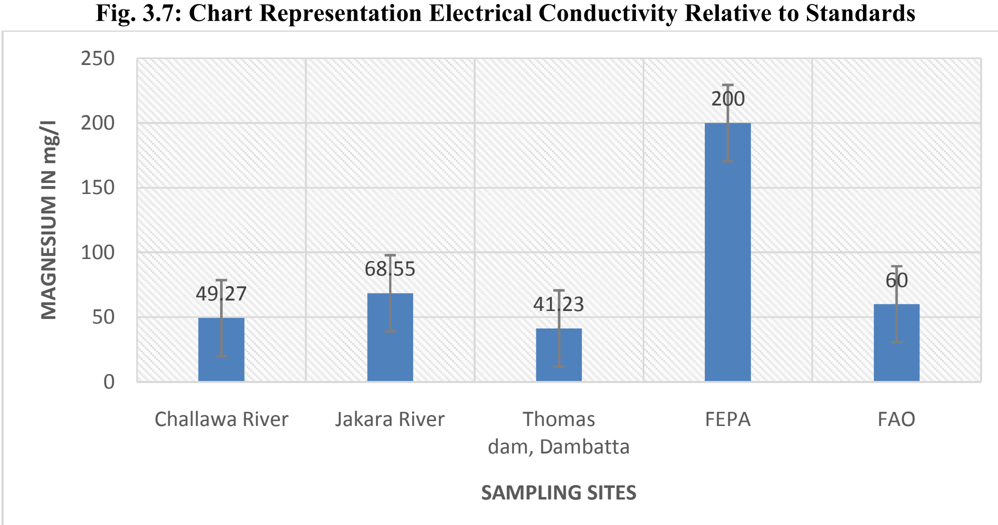

Fig. 3.8: Chart Representation of Magnesium Relative to Standards

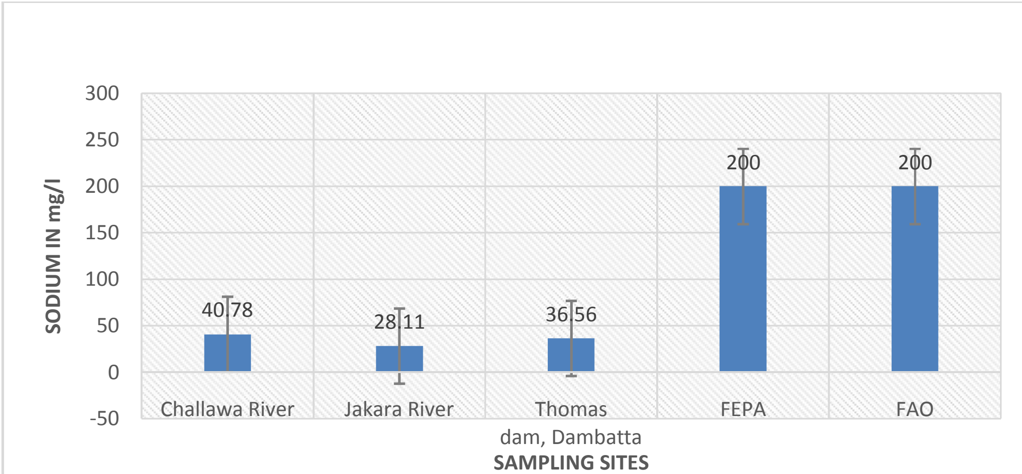

Fig. 3.9: Chart Representation of Sodium Relative to Standards

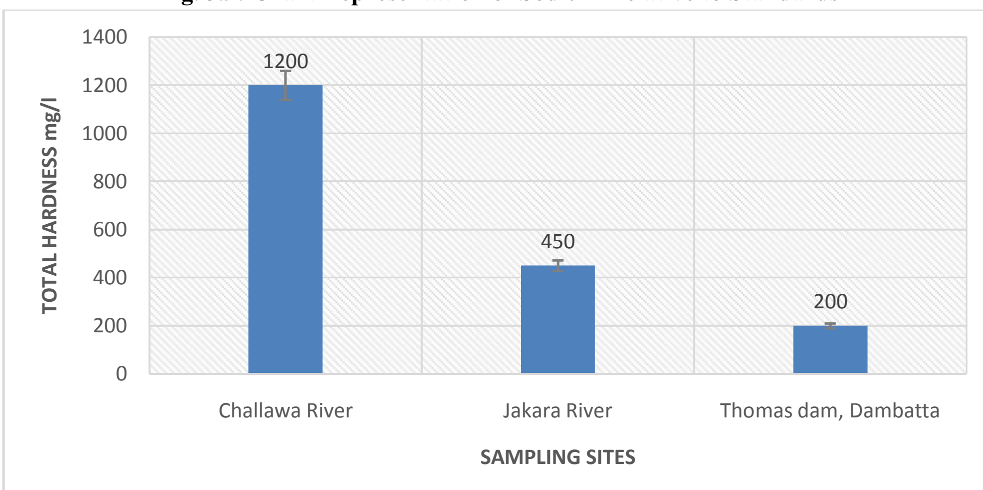

Fig. 3.10: Chart of the Total Hardness in irrigation water Samples

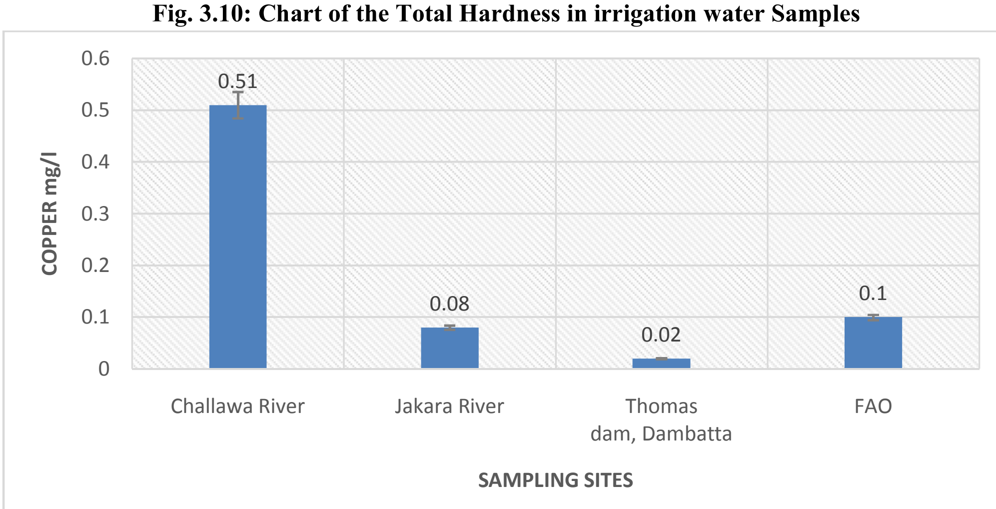

Fig. 3.11: Chart Representation of Copper

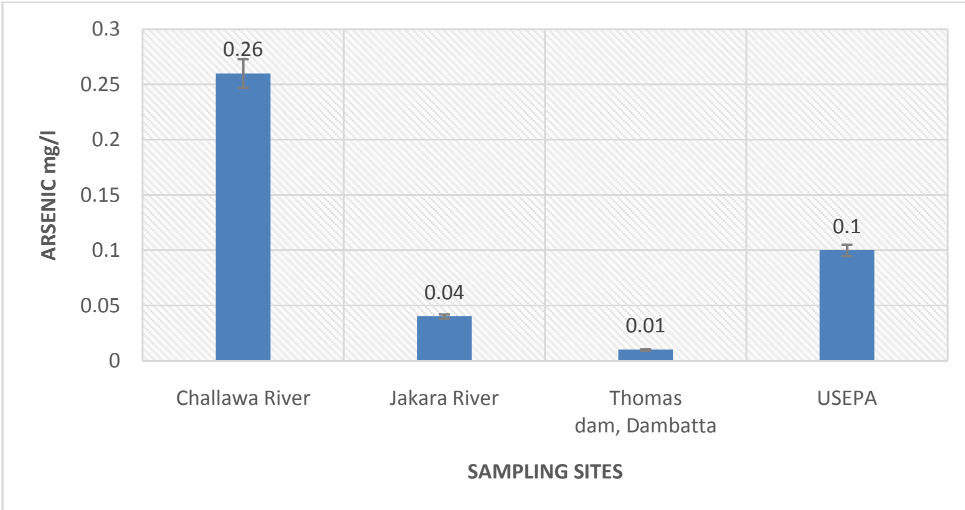

Fig. 3.12: Arsenic in Irrigation Water

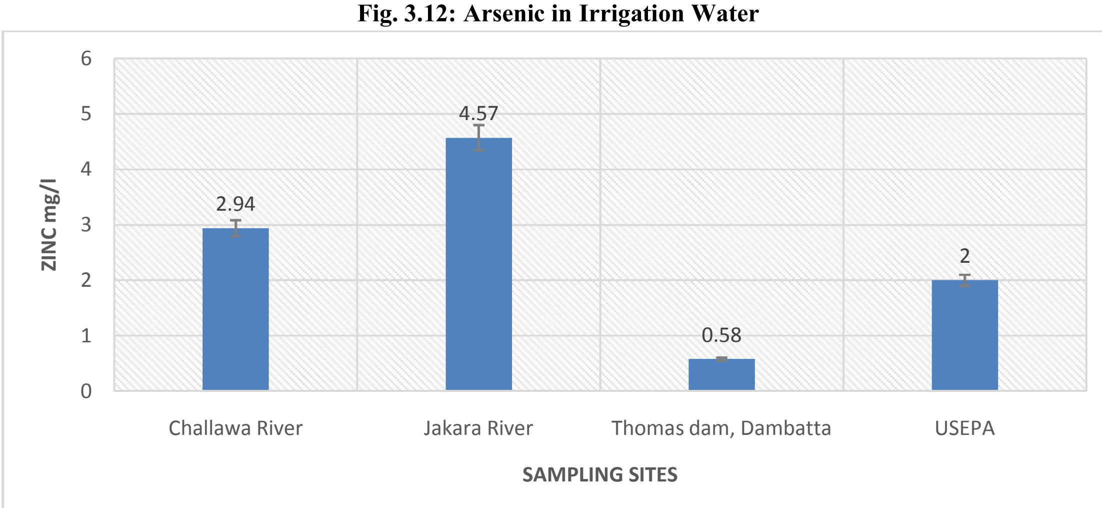

Fig. 3.13: Zinc Concentration in Chart

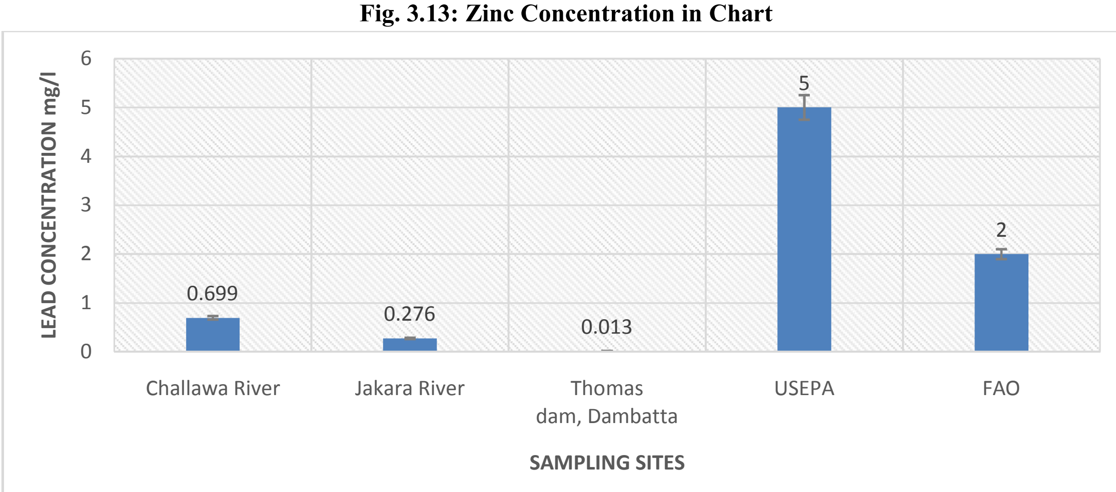

Fig. 3.14: Lead Concentration in the Irrigation Water

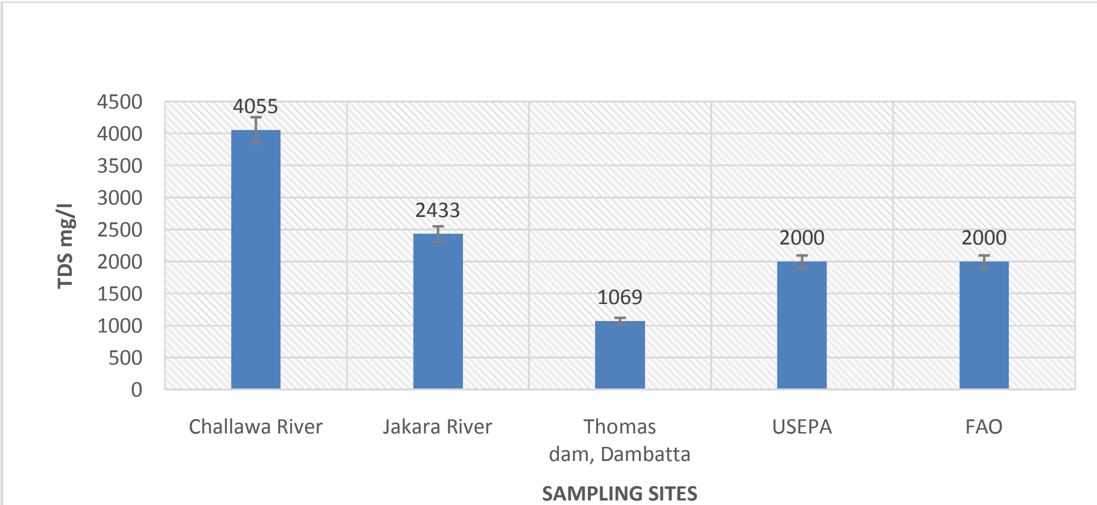

Fig. 3.15: Total Dissolved Solids (TDS)

IV. DISCUSSION OF RESULTS

Samples totalling 50 were collected from three different irrigation sites in and around Kano that include Challawa irrigation water, Jakara river water and Thomas dam, Dambatta between September 2024 and January, 2025 and tests conducted on them. Standard tests methods conducted was to ascertain the concentration of bacteriological and physicochemical parameters in the water used for irrigation in the above mentioned areas. The bacteriological parameters tested include *E. coli, Salmonella*, *Shigella, Vibrio Cholerae, Pseudomonas, and Total Coliform Bacteria (TCB).* The tests showed heavy presence of *E. coli, Salmonella, Vibrio Cholerae, Pseudomonas, and Total Coliform Bacteria (TCB)* in Challawa irrigation water source, negative only to *Shigella*. *Total Coliform Bacteria (TCB)* has exceeded the maximum acceptable limit of irrigation water of 1000counts/100ml of sample in all the tested irrigation water sources. The laboratory examination also detected that Jakara and Thomas dam irrigation water sources have all the bacteriological species (*E. coli, Salmonella, Shigella, Vibrio Cholerae, and Pseudomonas)*tested for. It therefore means that with the exception of Challawa irrigation water that showed negative result for *Shigella*only, all the three irrigation water sites have a clear and alarming presence of all the bacteriological parameters tested for. This reflects the ceaseless unhealthy activities in and around the affected areas. Aside faecal contamination that is common in those areas due to open defecation, there is also poor management of waste including sewage and other bacteria containing substances that eventually get washed into the irrigation water sources, making the heavy presence of bacteria in the irrigation water justifiable. On the other hand, the physicochemical parameters examined in the irrigation water and their concentrations for Challawa, Jakara and Thomas dam respectively, are: PH (1.9, 6.9, 7.2); Electrical Conductivity in µS/cm (8240, 1020, 430); Magnesium in mg/l (49.27, 68.55, 41.23); Sodium in mg/l (40.78, 28.11, 36.55); Total Hardness in mg/l (1200, 450, 200); Copper in mg/l (0.51, 0.08, 0.02); Arsenic in mg/l (0.26, 0.04, 0.01); Zinc in mg/l (2.94, 4.57, 0.58); Lead in mg/l (0.699, 0.276, 0.013); and Total Dissolved Solids in mg/l (4055, 2433, 1069). The concentration of Magnesium (Mg), Sodium (Na), Total Dissolved Solids (TDS), and Lead (Pb) for all the sampling sites have fallen within the recommended limits specified by FAO and FEPA. For PH, Copper (Cu), and Arsenic (Ar),only Challawa irrigation water violated the recommended guidelines. For Electrical conductivity (EC), Zinc (Zn), and Total Dissolved Solids (TDS), only Thomas dam irrigation water conforms to the recommended standard limit by USEPA and FEPA.

V. CONCLUSIONS

Three irrigation water sources in and around Kano metropolis have been examined and analysed for the amount of Physicochemical and Bacteriological parameters. The sources as mentioned earlier are: Challawa, Jakara (both within

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Kano Metropolis), and Thomas dam located at Dambatta. The primary aim of the research work is to check the suitability or otherwise of the use of these water sources for irrigation. These water sources have been the major sources of income for the inhabitants of the affected areas. But there is rising concern over the safety of the crops produced with the said water sources. This is because, so many unhealthy activities such as open defecation, dumping of waste from domestic and commercial activities including sewage in places that will eventually get into the irrigation water sources. These concerns apply to almost all the crops produced but it is more pronounced when referring to crops that are eaten in raw form like carrot, cabbage, and lettuce. All the water sources have indicated heavy bacterial loads including *Total Coliform Bacteria* that exceeded the maximum acceptable limit, making the water unsuitable in this regard. For the physicochemical parameters, the concentration of some of them like PH, Electrical Conductivity, signifying high salinity, and Total Dissolved solids suggest that the water is also unsuitable for irrigation.

Given the scarcity of water for irrigation in the area particularly during dry season, authorities must rise to the occasion and save the situation. Low PH can be neutralised by treating with basic substances such as calcium hydroxide. High electrical conductivity indicating high salinity can be reduced by certain treatment process such as reverse osmosis. On the side of the high bacterial load in the water, eating crops produced with water from these sources can be very dangerous to human health as the crops can carry disease causing agents by its contact with the contaminated water. Certain unhealthy activities must therefore be discouraged or even sanctioned by prescribing severe penalties to stop the practice and ensure that the high bacteriological load is reduced to an acceptable level. Governments and all other stakeholders must make effort to provide toilet facilities to discourage or even make policies and laws that criminalise open defecation as a preliminary control. Good waste management should be employed. Dumping of sewage in water must be avoided at all cost.

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