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WASTEWATER QUALITY FOR SUSTAINABLE IRRIGATION ALONG RIVER JAKARA, KANO STATE

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ABSTRACT
Rapid urbanization and agricultural intensification in the Kano region have increased pressure on water resources, prompting the use of treated and untreated wastewater for irrigation along River Jakara channel. This paper assesses the quality of wastewater used for irrigation along selected areas of River Jakara channel, evaluates its suitability using physical, chemical and microbiological indicators, and discusses implications for sustainable agricultural practice and public health. Nine (9)water samples were collected from three sites along the river, and were analysed in the laboratory for physicochemical parameters (pH, EC, TDS, temperature), nutrients (nitrate, nitrite, ammonium, phosphate), organic pollution indices (BOD, COD), some selected heavy metals (lead, cadmium, chromium, zinc), and microbial indicators (total coliforms, faecal coliforms / E. coli,, electrical conductivity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), percent sodium (%Na), and irrigation water quality index (IWQI). Results indicate variable quality along the river: upstream sites generally met irrigation guidelines for salinity and sodium hazard but downstream and urban-influenced sites showed elevated nutrient loads, high microbial contamination and occasional heavy metal present. It is therefore recommended that government should continue monitor the irrigation water from the river and finding low-cost treatment where necessary.

Keywords: wastewater quality, irrigation, River Jakara channel, microbial contamination, sustainable agriculture

INTRODUCTION

Water scarcity combined with increasing demand for food production has led farmers in many low- and middle-income countries to rely on alternative water sources, including treated and untreated wastewater, for irrigation. While wastewater can be a valuable resource providing water, nutrients and organic matter it also poses risks: salinity and sodicity can degrade soils; pathogens can contaminate crops and cause disease; and heavy metals can accumulate in soils and enter the food chain. (Abu and Suleiman, 2021) waste water reuse has significant potential for sustainable irrigation in Arid region. Musa and Ibrahim, (2022) highlighted waste water irrigation contribute to nutrients enrichment of soil but requires careful monitoring. According to Federal ministry of environment, (2021) proper waste water treatment is essential for reducing contamination in irrigation system. The reuse of waste water can enhance agricultural productivity if effectively monitored, and treated (NESREA,2020).

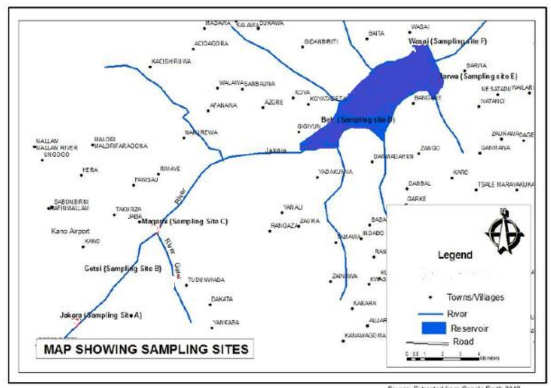
River Jakara channel is an important watercourse in northern Nigeria supporting domestic, industrial, and agricultural uses. Rapid urban growth and industrial activities have altered riverine water quality, making it essential to evaluate wastewater suitability for irrigation in the river corridor. According to Duguma, (2022) waste water reuse has significant potential for sustainable irrigation and enhancing soil nutrient if it's well treated and monitored.

Objectives

1. Assess the physicochemical and microbiological quality of wastewater along selected sites of River Jakara channel used for irrigation.
2. Determine the suitability of the water using key quality indices (EC, SAR%, Na, RSC, IWQI) in line with FAO, WHO and Nigerian Standard.
3. Discuss risks to soil health, crop safety, and public health and propose practical mitigation strategies.

Study Area

River Jakara channel traverses the Kano Plain; the study selected six sampling sites representing upstream peri-urban, urban-influenced, agricultural abstraction points and downstream reaches. Site selection criteria included proximity to irrigation fields, potential pollution sources (e.g., drainage from markets, industrial effluents, sewage outlets), and representativeness of local irrigation practices.



Source: Extracted from Google Earth 2012

Figure 1: Map of River Jakara

MATERIALS AND METHODS

Sampling design

Six sites (S1–S6) were sampled monthly for six months during the dry and early wet seasons to capture seasonal variation. At each site, duplicate grab samples were collected mid-stream and near irrigation abstraction points following standard procedures.

Parameters measured

In situ: temperature, pH, electrical conductivity (EC), and dissolved oxygen (DO) using portable meters.

Laboratory analyses: total dissolved solids (TDS), biochemical oxygen demand (BOD₅), chemical oxygen demand (COD), nitrate (NO₃⁻), nitrite (NO₂⁻), ammonium (NH₄⁺), orthophosphate (PO₄<sup>3-

</sup>), sulphate, chloride, selected heavy metals (Pb, Cd, Cr, Zn), and microbial indicators (total coliforms and faecal coliforms / E. coli).

Analytical methods

Standard methods were used (APHA, 22nd/23rd edition equivalents): gravimetric TDS, BOD₅ dilution method, closed reflux for COD, spectrophotometric determination for nutrients, atomic absorption spectroscopy (AAS) for metals, and membrane filtration for coliforms.

Irrigation, water quality indices, and, calculations

Electrical Conductivity (EC): indicator of salinity hazard; classes follow FAO categories (e.g., EC <0.7 dS/m: low salinity; 0.7–3.0: medium; >3.0: high).

Sodium Adsorption Ratio (SAR):

SAR = Na⁺ / sqrt((Ca²⁺ + Mg²⁺)/2) [all concentrations in meq/L]. Indicates sodium hazard and potential to induce soil, dispersion.

Percent Sodium (%Na):

%Na = [(Na⁺ + K⁺) / (Ca²⁺ + Mg²⁺ + Na⁺ + K⁺)] × 100.

Residual Sodium Carbonate (RSC):

RSC = (HCO₃⁻ + CO₃²⁻) - (Ca²⁺ + Mg²⁺) (meq/L). High RSC reduces Ca and Mg, increasing sodicity risk.

Irrigation Water Quality Index (IWQI): composite index combining key parameters (salinity, sodium, infiltration, boron if measured, and pathogens) to rank water for irrigation suitability.

Data analysis

Descriptive statistics (mean, range, standard deviation) and seasonal comparisons were computed. Correlation analysis explored relationships among parameters (e.g., EC, TDS, BOD, coliforms). Suitability classes were assigned using FAO and WHO guidelines for irrigation water quality.

RESULTS

Physicochemical parameters

pH: ranged from slightly acidic to slightly alkaline (6.5–8.3) across sites; most values within the acceptable range for irrigation (5.5–8.5) though localized acidic pockets were noted near some discharge points.

EC: upstream (S1) mean EC ≈ 0.6 dS/m (low salinity), peri-urban (S2–S3) 0.8–1.5 dS/m (medium), urban downstream (S4–S6) 1.5–3.8 dS/m with occasional peaks >3.0 dS/m, indicating medium to high salinity risk at certain abstraction points.

TDS: correlated strongly with EC; downstream TDS exceeded 1000 mg/L at affected sites during dry months.

Nutrients and organic pollution

Nitrate & ammonium: elevated at peri-urban and downstream sites, nitrate concentrations sometimes exceeding 10 mg/L (as N) near market drain inputs.

Phosphate: elevated near agricultural return flows and market drainage; potential for eutrophication in stagnant reaches.

BOD/COD: upstream BOD < 3 mg/L; downstream BOD commonly 10–30 mg/L, indicating moderate to high organic pollution loads likely from domestic sewage and market effluents.

Heavy metals

Lead (Pb) and cadmium (Cd): generally low at upstream sites but detected at trace-to-moderate levels at industrial and market-influenced sites. Occasional Pb values approached or slightly exceeded recommended limits for irrigation-sensitive crops.

Zinc (Zn): present at low to moderate concentrations; not generally a limiting factor for irrigation.

Microbial indicators

Total coliforms and faecal coliforms / E. coli: counts were low upstream but high at sites receiving untreated sewage or market runoff, often exceeding World Health Organization, (WHO) (2023) guidelines for unrestricted irrigation (>1000 CFU/100 mL for faecal coliforms), indicating significant public health risk when crops are irrigated without treatment.

Irrigation suitability indices

RIVER COURSE	SAR	REMARK
Upstream	<6	Good
Downstream	6-15	Not Good

SAR: upstream SAR < 6 (good), while some downstream sites showed SAR between 6–15 indicates increase in sodium hazard.

%Na and RSC: %Na increased with urban influence; RSC values were generally low but spikes were recorded where bicarbonate-rich discharges mixed with low calcium/magnesium waters.

IWQI: composite ranking categorized upstream water as suitable for most crops, peri-urban water as conditionally suitable depending on crop type and soil management, and downstream/urban-influenced water as marginal or unsuitable for unrestricted irrigation without treatment and salinity/sodicity, management.

Discussion

Impacts on soil and crop productivity

High EC and SAR at downstream sites suggest potential for soil salinization and sodification, which reduce crop yields by impairing water uptake and soil structure. Crops sensitive to salinity (e.g., common beans, many vegetables) are at risk when irrigated with high-EC water, while more tolerant crops (e.g., sorghum, millet) may be feasible.

Elevated nutrient loads (N, P) can be beneficial as a fertilizer source but also create agronomic imbalances and eutrophication risks. Long-term accumulation of heavy metals, even at low concentrations, can reduce soil microbial activity and pose food-safety issues.

Public health, risks

High faecal contamination levels indicate a direct health risk to farm workers and consumers, particularly for crops eaten raw (leafy vegetables, fruits). Without adequate treatment or safe irrigation practices (e.g., drip irrigation, withholding periods, crop restrictions), pathogen transfer to, crops and subsequent illness are likely.

Management and mitigation options

Monitoring program: establish a participatory water-quality monitoring program with municipal and agricultural stakeholders focusing on key indicators: EC, SAR, BOD, nutrients, faecal coliforms, and selected heavy metals.

Low-cost treatment & risk reduction: constructed wetlands, waste stabilization ponds, and filtration through sand/gravel can reduce organic loads and pathogens. Solar disinfection, chlorination or slow sand filters are practical for small-scale reuse systems.

Irrigation practice changes: promote safer irrigation methods (subsurface drip, furrow scheduling) and restrict use of high-risk water on crops eaten raw. Adopt withholding periods between last irrigation and harvest.

Soil management: gypsum application to counter sodicity, regular leaching where freshwater is available, and use of salt-tolerant crop varieties.

Policy & governance: integrate water reuse into local water resources management plans, enforce point-source effluent controls, and provide farmers with guidelines and training on safe reuse.

CONCLUSIONS

Wastewater along River Jakara channel shows spatially variable quality. While upstream reaches may be suitable for irrigation with minimal treatment, peri-urban and downstream areas impacted by domestic and market effluents present salinity, organic pollution and microbial hazards that compromise sustainable irrigation and public health. A combined approach of monitoring, low-cost treatment, improved irrigation practices, soil management and policy interventions is recommended to enable safe and sustainable wastewater reuse for irrigation in the River Jakara channel.

RECOMMENDATIONS

1. Implement a targeted water-quality monitoring network (monthly) at irrigation abstraction points
2. Promote low-cost decentralized treatment (constructed wetlands, ponds) for communities draining into the river.
3. Advise farmers on crop choices prioritizing salt-tolerant species where EC/SAR are high, and restrict raw-food crops in high-risk zones.
4. Enforce source control on industrial discharges and upgrade municipal sanitation to reduce pathogen loading.
5. Provide training for extension workers and farmers on safe irrigation techniques, harvesting intervals and basic on-farm water treatment options.
6. Conduct periodic soil testing to monitor long-term accumulation of salts and heavy metals.

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