International Research Journal of Earth Sciences _____ ISSN 2321 – 2527
Vol. **8(2),** 66-73, August **(2020)** *Int. Res. J. Earth Sci.*

Review Paper

Achieving sustainable use and management of water resources for irrigation in Nigeria

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Available online at: www.isca.in
Received 18th September 2019, revised 1st July 2020, accepted 30th July 2020

Abstract

Water resource is available in Nigeria to meet water demand for domestic, agricultural and industrial use. If well enhanced and protected from various source of pollution. However, less information is available on suitability of water resources for irrigation use in Nigeria. This article reviews literature of the past few years with regards to influence of geogenic and anthropogenic activities on water resource for irrigation purpose in Nigeria and also to explain the current state of suitability of water resource for irrigation studies in Nigeria and gaps in studies. It also summarizes future ways on water resource management and preventive measure for water resource pollution for irrigation. Related articles were downloaded from Google scholar in water-related issues. This paper tends to review previous article on water resource in Nigeria, and its suitability for irrigation. The primary aim of this paper is to produce a synoptic overview of the water resources in Nigeria and its suitability for irrigation use. From paper reviewed it was observed that 89% of water resources was considered suitable for irrigation.

Keywords: Geogenic, Anthropogenic, Irrigation Indices, Suitability and Nigeria.

Introduction

Recent studies have shown that scientific approach such statistical based approach, hydrochemical and other approach has been used for water resources quality assessment. With these approach, large geological, hydrological and biological data are simplified, organized and classified to produce useful information on water quality for various use ranging from domestic, industrial, irrigation and other use[1-5]. As the quality of water resource is most time influenced by geogenic and anthropogenic activities. The hydrogeochemical characteristics of groundwater is governed and influenced by groundwater quality and the rock/mineral-water interactions in the sub-surface aquifers and sometimes by inter mixing of two different aquifers[6]. Johnson, et al.[7] pointed out that the most widespread forms of geogenic contamination with effect on man and crops are elevated concentrations of arsenic and fluoride. Geogenic contamination may also trigger concentrations of uranium[8,9], chloride[10] or sulfate[11]. Grützmacher, et al.[12] stated that geogenic contamination is defined as the overstepping of certain thresholds (drinking water guidelines) in the groundwater without direct or indirect human influence. Often it is the result of long residence times combined with favorable geologic conditions and mineralogy of the groundwater. Several studies carried out has shown that hat anthropogenic activities resulting in its urbanization, mining, industrialization, landfill/dumpsite, pesticides washed off the land by rain, leachates, heavy metals, bacteriological pollution, overexploitation, poor recharge and chemical contamination are major concerns for groundwater sustainability[13-16]. While in coastal area of Nigeria and other part of the world salinization has become a threat to groundwater quality. Numerous publication have reported salinization and potential sources of groundwater salinity in coastal groundwater, these include evaporite mineral dissolution[17-19], downward/upward saline groundwater seepage[20-22], brine migration[23-24], and mixing caused by poorly constructed wells[25], as well as seawater intrusion[26]. Studies by Ocheri, et al.[27] stated that groundwater quality in cities areas are mostly controlled by the geogenic and geochemistry of the environment, rate of urbanization, landfill/dumpsite leachates, industrialization, bacteriological pollution, heavy metals, and effect of seasons. In the vein, surface water contamination is linked to increase in population, urbanization and industrialization. The potability of water resources for irrigation is evaluated by its mineralogy makeup, the type of the plant and the soil to be irrigated[28]. The objectives of this study are to review potability of water resources in Nigeria for irrigation based on two category: i. Anthropogenic; these include; mining activities, unlawful waste disposal, leakage of septic tanks and application of pesticides. ii. Geogenic factor; these include weathering and rock water interaction.

Climate and Vegetation: The study area is grouped into five vegetation zones namely; the coastal zone, tropical rainforest,

Guinea Savannah, Sudan Savannah and Sahel[29]. The climatic zones are shown in Figure-1 and grouped following the agro-climatic zones distribution (based mainly on rainfall and temperature) of the country, see Ayanlade, *et al*.[30] for more information as regards this.

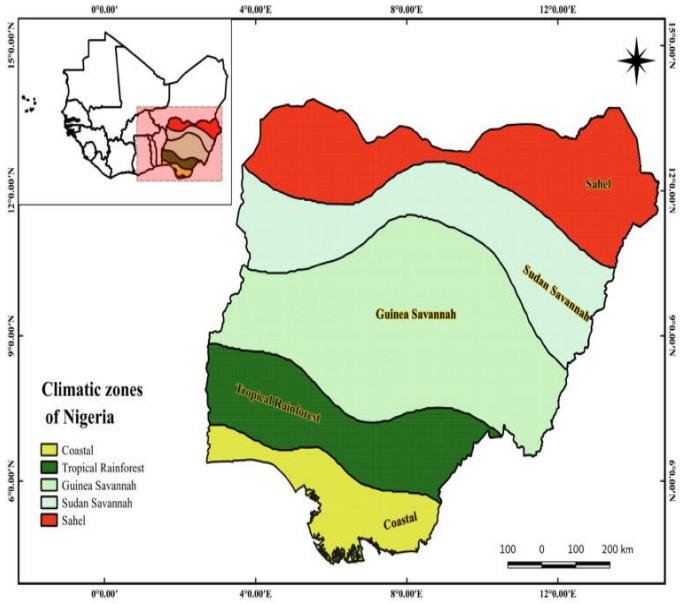

Figure-1: Map showing Climatic zones in Nigeria; adapted from Akinsanola and Ogunjobi[29].

Geology Setting: Geology of the Nigeria is divided into; Basement Complex, Younger granites, and Sedimentary Basins (Figure-2)[31].

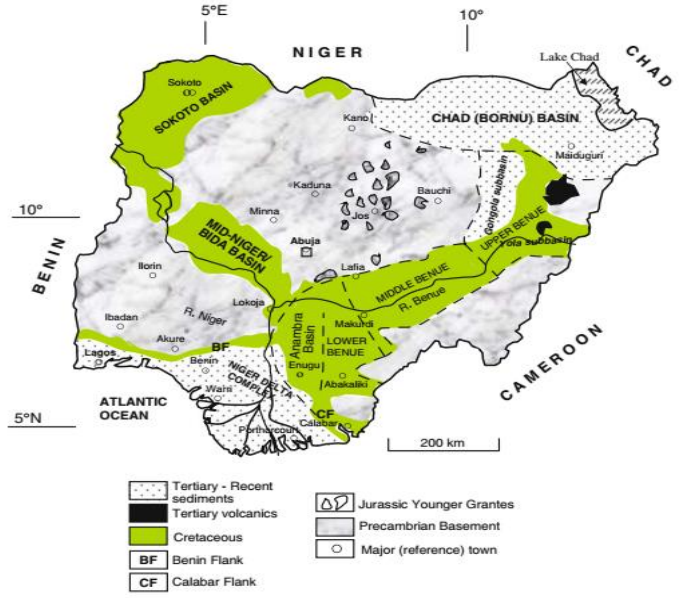

Figure-2: Map of Nigeria showing three major geological component Basement, Younger Granites, and Sedimentary Basins[32].

Methodology

Articles published within the last 5-10 years were reviewed to evaluate the influence of anthprogenic and geogenic activities on water resources quality and its suitability for irrigation use in Nigeria and also abate measure to reduce water resource pollution. Omlin, *et al*.[33], methods was adopted for this study. Article related to this study were searched by google search engines, open access journal sites (SCOPUS, Pub-Med, Taylor Francis, Elsevier and Springer etc.). These relevant articles and papers were read in full information gotten was stored in database with details of publication particulars, study location, period, approach, methodology for assessing influence of anthropogenic and geogenic activities, results of these activities, and major conclusion. Furthermore, to interpret the status and quality of work carried out in Nigeria, Omlin, *et al*[33] method was employed for this study with some modifications to suit the aim and objectives of this paper. The steps that was adopted to evaluate the quality of the articles included the following; i. Geological terrain of were each of the paper belongs to (Basement complex, sedimentary basin and Niger Delta Basin), ii. Detail description of subjective exposure of water resources was discussed (precipitation, water rock interaction, mining activities.

Result and discussion

Factor that alter water resources quality for irrigation use in Nigeria (with emphasis on geogenic and anthropogenic activities). i. Geogenic (rock water interaction, weathering. e.t.c), ii. Anthropogenic activities (marine pollution, sewage disposal, leakage of septic tanks and mining).

Related article on geogenic factors: Aderibigbe, *et al*.[34] studied the potability of water resources for irrigation. Irrigation indices that they calculated for was Na%, from their study it was observed that water resources were within the excellent to permissible class, there study further revealed that the ions present in these water bodies are dominantly controlled by chemical weathering and none was assigned to precipitation processes. Eyankware[35] evaluated the groundwater quality at Ekaeru Inyimagu for irrigation using hydrochemical approach and irrigation indices findings from the study revealed that groundwater within the area of study was considered suitable for irrigation. Further results, from the findings revealed that the dominant species in groundwater is Cl^-, result from Gibbs plot, further showed that rock water interaction is the major process that influencing groundwater chemistry. Estimated result from irrigation indices showed that soluble sodium percentage (SSP), magnesium absorption ratio (MAR), Permeability index (PI), residual sodium bicarbonate (RSBC) and Kelly ratio (KR) fell within excellent to very good range, hence one could say groundwater for the study is considered suitable for irrigation. Ayuba, *et al*[36] evaluated different rural communities wells, this positive correlation is an indication that the ions are controlled by the same geochemical factors[35], further stated that based on

(sodium percentage) Na % only one sample location has Na% less than 20% and it is classified excellent water type. Irrigation parameters calculated for were sodium percentage (Na%), SAR, magnesium hardness (MAR), PI and RSC. The RSC, MH, estimated from groundwater sample revealed that the values were parameters were below the guideline of 60% and thus, are considered to be safe and fit for irrigation purposes. Eyankware, *et al*.[37] studied the suitability of water resources for irrigation in abandoned Nkalagu limestone mine pits, Ebonyi state Southeastern Nigeria. Indices calculated for were SSP, MAR, KR, Na%, SAR and TH. They stated that most of calculated parameters were considered suitable for irrigation, few sampling were considered unfit for irrigation and that high concentrations of the magnesium and calcium showed that the area is of carbonate terrain and there is evidence of water rock interaction. Oladeji, *et al*[38] evaluated the quality of groundwater for irrigation at Otte village, Kwara state Nigeria within two geologic formation Migmatitic and Granitic gnesis. They concluded that the water samples obtained from areas underlain by the Migmatitic gneiss tends to be relatively suitable for irrigation, when compared to those underlain by the Granitic gneiss. Talabi, *et al*. [39] studied surface water and shallow water bearing formation in Ekiti state, the area falls within the Basement Complex, there study was subjected to seasonal variation. Findings from there revealed that 90% of TH from surface water showed is less than 70 mg/L this implies that surface water is considered soft, with low effect of mineralized water and no pronounced effect of water interaction from transient to residence time. They further pointed out that irrigation indices such as; SAR, RSBC and PI showed signified good quality water suitable for irrigation, while MAR and Kelly's ratio were indicative of moderately suitable irrigation water. Aleke and Nwachukwu[40] studied the suitability of basement aquifer at Abuja, Nigeria, for irrigation. They were of the opinion that geochemical facies of the groundwater is of Ca–Cl_2 water type, this implies that over a long period of time, water-rock interaction has altered groundwater chemistry[41], their findings revealed that the major processes influencing groundwater are weathering, mineral dissolution and ion exchange. Irrigation indices such as SAR, KR, TH, PI, and RSC showed that the groundwater within the study area is suitable for irrigation, except MR which showed that groundwater is fairly unsuitable for irrigation. According to Talabi[41] stated that groundwater is suitable for irrigation, and further stated that rock water interaction influence its chemistry as it reflect on it physicochemical composition, water facies and irrigation quality. Hence groundwater within selected part of Ikere, Ekiti is considered fit for irrigation. Omo-Irabor, *et al*.[42] stated that pH shows that groundwater falls within slightly acidic to basic, and are within acceptable range for irrigation purpose. They evaluated groundwater at Ibinta with emphasis on its suitability for irrigation, from hydrogeochemical facies plot, the dominant water type from piper plot is SO_4^{2-} + Mg^{2+} type, from Scholler diagram groundwater trend in Mg^{2+}>SO_4^{2-}>Cl^->HCO_3^->Na^+ >Ca^+ and the Wilcox diagram showed that the groundwater ranges between permissible to excellent class, Gibbs plot revealed that rock water interaction is the major process that influence groundwater. Result from irrigation parameters revealed that SSP, Na%, KR and TH were below the permissible limit for irrigation, based on these ground water is considered fit for irrigation. Talabi, *et al*.[39] assessed the suitability of surface water for irrigation using indices such as SAR, RSC, PI and KR results from their study showed that surface water fell within excellent to good[31], Gibbs plot depicted that the geochemistry of water were influenced by chemical weathering controlled by precipitation as the major factor controlling the chemistry of the surface waters. According to Nwankwoala, *et al*.[43] higher percentage of groundwater model in selected part of Otuoke and environs, Bayelsa State were considered suitable for irrigation purpose except for KR, its suitability status were assessed using irrigation models such as; SAR, PS, PI, Na %, KR, and MAR. Onyeabor and Nwatalari[44] assessed surface water around Enyigba mine for irrigation, model use for the evaluation was SAR, from their findings they stated that the water is fit for irrigation. Egirani and Nomji[45] assessed groundwater in Markurdi, Benue state capital. A total of eight groundwater sample were analyzed from there finding it was observed that water is considered suitable for irrigation. In the same vein Ekpe, *et al*[46] assessed surface and groundwater in selected water resource in southeastern Nigeria. Their findings revealed that water resources were considered suitable for irrigation. Eyankware, et al.[47] evaluated groundwater of Oju, Benue State with emphasis on its suitability for irrigation, indices used to assess the suitability of sampled water were Ec, MAR, SAR, TH, Na%, SSP, Gibbs plot and plot of SAR against Ec. Their findings showed that over 94% of sampled point where considered suitable for irrigation, although high TH value was observed at some and hence such points were considered unsuitable for irrigation.

Related article on anthropogenic activities: Eyankware, *et al*.[48] conducted an assessment of influence of mining of water quality for irrigation at Mkpuma Ekwaoku mining district. Parameters analyzed for were; TH, SAR, MAR, KR, Na % and SSP. From there findings, it was observed that TH and Na% at some sampling points were slightly above the set standard, that implies mining might have affected the suitability of water for irrigation at those points that are above the set standard. Ethan, *et al*.[49] evaluated of water quality for irrigation at Badeggi and Edozigdi, indices calculated for were SAR and Na%. They stated that the quality of water resources for irrigation falls within moderate category according to FAO Standard[50]. Omotoso and Ojo[51] studied the quality of river Niger floodplain water at Jebba central for irrigation. Indices calculated for where SAR, MAR, RSC, permeability index (PI), Potential salinity (PS) and SSP. From there findings, the water is of suitable for irrigation. Except for magnesium absorption ratio and Kelly ratio at some locations where considered unfit for irrigation[43], stated that surface water (River Niger, Oshin and Ndafa) were used for Josepdam irrigation scheme. From their findings water show no salinity tendency from SAR value, while pH is within the recommended FAO standard[50]. Eyankware, *et al*.[52]

evaluated groundwater quality for irrigation at Warri, Niger Delta Region. Irrigation parameters calculated for were; SSP, MAR, SAR, PI and PS. They observed that SSP, MAR, SAR, PI, EC, Potential salinity (PS) were below the set standard and considered fit for irrigation purpose. Except for TH and KR that were above the set standard at some sampling points, concluded that groundwater is considered fairly good for irrigation. Eyankware, *et al*.[53] studied the suitability of groundwater for irrigation at Eruemukohwarien Community, Niger Delta Region. Indices calculated for were: SAR, KR, MAR, PI, Na % and SSP, their results showed that groundwater was considered suitable for irrigation. Eyankware[54] evaluated the impact of mining on groundwater within the Umuoghara mining district in Ebonyi State, southeastern Nigeria. Geologically, the area lies within the Asu River Group of Southern Benue Trough. Irrigation parameters such as PI values were below the set standard for irrigation. Values of KR, RSBC, SSP, Na%, TH and Ec were above the set standard at some sampling points. Tsuzom, *et al*.[55] studied surface water quality at Kaduna from their findings it was observed Ec and potassium concentration in sampled water were above the irrigation guideline values across the sampling points; boron concentrations were close to guideline value at two sampled point, estimated values from SAR exceeded the guideline value at four of the six sampling points. Their findings showed the need for the Nasarawa stream water to be subjected to some level of treatment especially during the dry season when the level of dilution by rain water will be absent and then water will be considered suitable for irrigation. Tsuzom and Olaniya[55] studied the suitability of Nasarawa stream for irrigation in Kaduna south local government. Irrigation indices applied for this study were SAR, RSC and Ec. Results from their studies revealed that indices studied were below the set standard. Hence sampled water is considered suitable for irrigation. Akpan, et al.[56] access the potability of Okpaku River using SAR as irrigation indices for evaluation of sodicity hazard for irrigation. From their findings it was observed that sampled points were below specific standard for irrigation. Although, other irrigation indices was not used to confirm the suitability of the sampled water for irrigation, hence their findings was not scientific proven.

Table-1: Related references on water resource studies for irrigation quality in Nigeria.

Location	Geology	Data Source	Field of Study	Sample No	Year of Publication	Title	Ref.
Benue	Sedimentary terrain	Journal article	Water analysis	8	2002	Preliminary investigation of the hydro-geochemical characteristics of groundwater in parts of the Makurdi formation, Nigeria	45
Kwara	Basement	Journal article	Water analysis	12	2012	Suitability assessment of groundwater resources for irrigation around Otte Village, Kwara State, Nigeria	38
Jebba		Journal article	Water analysis		2012	Assessment of quality of river Niger floodplain water at Jebba, central Nigeria: implications for irrigation	51
Cross River	Sedimentary terrain	Journal article	Water analysis	17	2012	Water Quality Assessment of Okpaukpu River for Drinking and Irrigation Use in Yala, Cross River State. Nigeria.	56
Niger		Journal article	Water analysis		2014	Assessment of the Quality of Irrigation Water at the Badeggi and Edozighi Irrigation Schemes	49
Ebonyi	Sedimentary terrain	Journal article	Water analysis		2014	Miscellaneous Properties of Irrigation Water Sources of Ebonyi State Southeast Nigeria	46
Kaduna		Journal article	Water analysis	6	2015	Stream Water Quality Assessment for Irrigation at Nasarawa - Kakuri Area of Kaduna, Nigeria.	55
Ebonyi	Sedimentary terrain	Journal article	Water analysis	6	2016a	Hydrochemical Apprasial of Groundwater for Irrigation Purpose; a case study of Ekaeru Inyimagu and its adjoining area, Ebonyi State, Nigeria	35
Ebonyi	Sedimentary terrain	Journal article	Water analysis	10	2016b	Use of hydrochemical Approach in Evaluation Water Quality around the Vicinity of Mkpuma Ekwaoku Mining District, Ebonyi State, SE. Nigeria for Irrigation Purpose	48
Ebonyi	Sedimentary terrain	Journal article	Water analysis	12	2017c	Hydrogeochemical Evaluation of Groundwater for Irrigation Purposes in Mining Areas of Umuoghara Near, Abakaliki, SE. Nigeria.	54

Delta	Sedimentary terrain	Journal article	Water analysis	15	2016	Hydrogeochemical Assessment of Ground and Surface water of Eruemukohwarien Community and its Environs for Domestic and Irrigation purpose, Western Niger Delta Region, Nigeria.	53
Ekiti		Journal article	Water analysis	22	2017	The Suitability of Groundwater for Domestic and Irrigation Purposes: A Case Study of Ikere Ekiti, SW-Nigeria.	41
Lagos	Sedimentary terrain	Journal article	Water analysis	14	2015	Hydrochemical Studies of Surface Water and Groundwater in Lagos State, Southwest Nigeria.	35
Benue	Sedimentary terrain	Journal article	Water analysis	18	2017	Hydrochemical Characteristics and quality Assessment of Groundwater from Shallow Wells in Gboloko Area, Central Nigeria.	36
Ebonyi	Sedimentary terrain	Journal article	Water analysis	13	2018a	Geochemical Assessment of Water Quality for Irrigation Purpose, in Abandoned Limestone Quarry pit at Nkalagu area, Southern Benue Trough	37
Delta	Sedimentary terrain	Journal article	Water analysis	15	2020	Hydrogeochemical Appraisal of Water Quality for Irrigation at Warri and environs. Niger Delta Basin, Nigeria.	52
Bayelsa	Sedimentary terrain	Journal article	Water analysis	14	2018	Geochemical Assessment and Modeling of Water Quality for Irrigation and Industrial Purposes in Otuoke and Environs, Bayelsa State, Nigeria.	43
Ebonyi	Sedimentary terrain	Journal article	Water analysis	6	2018	Irrigation Suitability of Surface Waters of Enyigba Ebonyi State, Southeastern Nigeria	44
Abuja	Basement Complex	Journal article	Water analysis	15	2019	Assessment and characterization of the Basement aquifer at Idu–Karmo, area of FCT-Abuja, Nigeria, for drinking and irrigation	40
Cross River	Sedimentary terrain	Journal article	Water analysis	15	2018	Integration of Hydrogeochemical Analytical Methods and Irrigation Parameters in the Evaluation of Groundwater Quality at Ibinta, Southern Benue Trough Nigeria	42
Oju, Benue State	Sedimentary terrain	Journal article	Water analysis	14	2019	Evaluation of the Process Governing Groundwater Suitability for Irrigation at Oju and its Adjourning Area, Benue State, Nigeria. Using Hydrochemical Approach.	51

Usage of Water resource for irrigation: Findings from the literature analysis revealed that groundwater is more evaluated for irrigation purposed than surface water. Surface water is believed to be more prone to pollution when compared to surface due to the fact it exposed to all kind of pollutant i.e landfill, septic tanks and oil spill.

Although groundwater is not easily polluted when compared to surface water, but it could be difficult to remediate contaminants once pollution occurs[57,58]. It was observed that groundwater was evaluated more for groundwater with percentage of 79.6 % when compared to surface water with 20.4 % as shown in Figure-3.

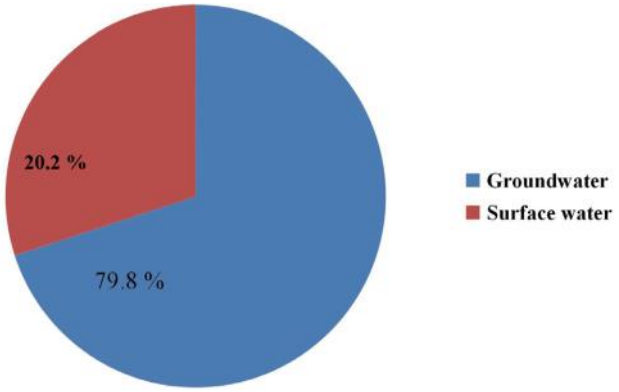

Figure- 3: Percentage of Groundwater/surface water evaluated for Irrigation in Nigeria.

Type of pollutant that alter water quality for Irrigation in Nigeria: Various kind of pollutant are responsible for water quality alteration for irrigation in Nigeria, such factors could be domestic waste, acid-rain that occur in oil and gas producing region of Niger Delta Region of Nigeria[59] suggested that sources of surface water pollution in Nigeria are solid mineral exploration, oil and gas, industrial effluent, hydrogeology, domestic waste and sewage, and agriculture. They further stated that groundwater pollution in Nigeria are landfill leachate, hydrogeology, industrial effluent, urbanization, poor well construction, domestic waste and sewage and, oil and gas.

Conclusion

From detailed review, it was observed that unsuitability of groundwater for irrigation use could be attributed to anthropogenic activities, geogenic activities. From reviewed literature, it was observed that 59% of within groundwater the sedimentary terrain is influenced by rock-water interaction, 41 % is influenced by anthropogenic activities, while, within the hard rock terrain 67% of water resources is influenced by geogenic activities, 33% is influenced by anthropogenic activities. Irrigation indices such as SAR, TH, SSP, Na%, MAR, CAI, RSBC, KR, PI Gibbs plots and PI, showed that 71% of water resource in Nigeria was considered suitable for irrigation, 29% is considered slightly unsuitable for irrigation, various authors revealed that the unsuitability of groundwater for irrigation, could be linked to mineralogy constituents of water bearing units for both hard rock and sedimentary terrain. Irrigation parameters analyzed by various authors revealed that 90% of analyzed water falls within excellent and good category. Various authors were of the opinion, that although groundwater chemistry was influenced by weathering processes it's has little or no influence on suitability of water resources for irrigation.

Recommendations: In addressing these aforementioned challenges, the following recommendation should be taken into consideration; i. Relevant law enforcement agencies should try and enforce strict adherent to disposal of waste close to surface water bodies to avoid decline in surface water quality. ii. Relevant authorities should ensure that water quality criteria should be used as a guideline to define proper management practices in irrigated agriculture. iii. Water resources (quality) should be monitored from time to time by relevant agencies to avoid total deterioration of water quality for irrigation.

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