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Efficient Management of Resources: Wastewater Application in Dry Season Farming in Kaduna Urban Area Nigeria

[1]K.I. Samaila, [1]N.D. Marcus and [2]S.B. Momale
[1]Department of Geography, Nasarawa State University, Keffi, Nigeria
[2]Department of Geography, Bayero University, Kano, Nigeria

Abstract: The expanding demands for agricultural products by the growing population in the developing economies have suffered serious setbacks over the last decades from climatic inconsistency. Irrigation therefore, offers a promising alternative in augmenting rain fed agriculture and boosts agricultural production. In most urban Nigerian cities, wastewaters from industrial and domestic operations are disposed into surface water, receiving bodies culminating into water management problems. Wastewaters in the drainage system due to their constant supply and their perennial nature are attractive, dependable and reliable water source for irrigation. This study investigates, the perception of farmers on the effects of wastewater, reuse for irrigation development and its implication as a management strategy. Structured questionnaires were administered to 200 respondents on irrigated fields near drains served by industrial effluents or domestic sewage. Focused group discussion was also organized along side the questionnaires. Result of analysis indicates that though the reuse of wastewater is popular with most farmers, it is however observed that it is likely to be accompanied by potential environmental and health problems. For irrigation to offer opportunity to manage wastewaters in the area with minimum adverse environmental effects proper management of crops, soils and water must be pursued vigorously. The study also proffers recommendations for the reuse of wastewaters for irrigation in Nigeria such as selection of tolerant crops, some form of treatment before discharge into water recipient surfaces and monitoring of wastewater at point of generation.

Key words: Wastewaters, management, reuse, application and irrigation, inconsistency, Nigeria

INTRODUCTION

Human activities such as industrial, agricultural, domestic and mining contribute in releasing waste substances into surface water, bodies receiving effluents from areas affected with such activities. Such wastes can alter the inherent physical, biological and chemical properties of water.

According to Feachem *et al*. (1982), the use of surface water for irrigation imposes the least restrictive quality standards and will often allow the free discharge of wastewater. With proper management, wastewater may augment surface water in streams, canals, ponds, lakes, lagoons and as well recharge underground aquifers. Wastewaters can be reclaimed by partially purifying the waste fluids from one process and reuse the water for other processes.

Studies have shown that irrigation represents not only an appropriate disposal medium for many wastes but also an opportunity to manage wastes with minimum adverse environmental effects. When wastewater is used for irrigation the potential treatment mechanisms are many which include biological oxidation, ion exchange, chemical precipitation, absorption and assimilation into growing plants and animals. Wastewater in most Nigerian cities is mainly from three sources namely industrial effluents, agricultural return flow and domestic wastewaters which subsequently find their way into the natural drainage system to raise the quantity of water in receiving surfaces. Though, quantity of water is increased, however its quality is depleted due to excessive presence of hazardous particulates.

In many urban areas, especially the developing worlds, wastewater is recycled in a variety of ways of which dry season irrigation farming is the commonest (Prescod, 1992; Jimenez and Landa, 1998; Madyiwa *et al*., 2002).

Wastewater due to its constant supply and perennial nature, offers a more dependable, reliable and consistent source of water for irrigation. For example, it is argued that along the Musi river in Andre Pradesh, India wastewater contributes to food security by providing water for livelihood activities that is reliable, sufficient and available in demand (Buechler and Devi, 2004). Researches have

Corresponding Author: N.D. Marcus, Department of Geography, Nasarawa State University, Keffi, Nigeria

indicated that wastewater contain some appreciable concentration of metallic and non-metallic ions toxic and non-toxic compounds must of which when applied to the soil during irrigation may improve soil nutrients availability (Papadopoulos, 1988; Prescod, 1992). As observed by Ademorati wastewater augments available water resources and its reuse for irrigation is advantageous as it contains some valuable plant nutrients, especially if present within tolerable limits.

The presence of anions such as phosphorus and nitrogen which are important macronutrients and cations like calcium, magnesium and potassium aid rapid plants growth and ensure good yields. In addition to this, Boughey (1975) observed that eutrophication is avoidable if nitrates and phosphates are removed from sewage effluents and applied to crops in such a manner that they do not drain off immediately.

The reuse of sewage effluents for irrigation has been observed to be advantageous as the amount of artificial fertilizer to be applied on farm plots is substantially reduced or eliminated in some cases. In Australia, irrigation of field crops, forests and pastures by effluents have been in practice for years without apparent ill effect and in China raw sewage has been applied on rice fields and with positive results. As observed by William farmers are often glad to have the sludge from wastes spread on their fields for its fertilizer contents.

Wastewater when used for irrigation is completely recycled on the land by evaporation, transpiration, incorporated into plants or percolated into the subsoil. Though, irrigation offers a technically cheaper and easier form of wastewater management, the reuse of wastewater directly for irrigation is likely to be accompanied by increase in the quantities of certain ions in the soil at levels likely to be detrimental to normal plants developmental processes (James, 1993).

According to Musa concern on the use of wastewater for irrigation lies in bacterial contamination of the produce and the accumulation of heavy metals which though, small in concentrations are toxic to human health and also pose health hazards to marine biodiversity. It is in this respect that Samaila recommends that time lag between irrigation with wastewater and harvesting period be observed for irrigated crops and that crops eaten raw should not be irrigated with wastewater. The use of wastewater for irrigation however, allows the free discharge of wastewater into terrestrial environmental systems thus offering a cheap mean of water management in the developing economies.

Kaduna town was once, the regional administrative headquarter of Northern Nigeria and it is now the capital of Kaduna state in North Central Nigeria. The town is one of the industrialized urban centers in Nigeria and has a variety of industries established far back colonial era long before independence in 1960. Most of the industries are textiles and breweries which generate substantial quantity of wastewater into the existing surface drainage system. The release of wastewaters from industries and domestic operations has increased water availability in streams and River Kaduna and has as well increased water pollution in the area.

The permanency of wastewaters in the natural drainage system has attracted irrigation development along most watercourses in the town. To meet food demands of its bourgeoning population residents of the town, therefore have ventured into urban farming making use of wastewater to irrigate crops. The UNDP (1978) however, observed that this is because of no alternative source of water for irrigation and farmers have to use what is available.

Previous studies on wastewater use in irrigation in Kaduna urban area have concentrated on assessing the changes in quality of irrigated soils resulting from the application of wastewater. Studies have thus not been conducted on the people's perception of issues related to the use of wastewater application in irrigation, especially their perception of problems associated with the usage. The study is thus initiated with the central objective of documenting the perception of irrigation farmers of some issues relating to the use of wastewater in irrigation in Kaduna urban area.

MATERIALS AND METHODS

The study was carried out in Kaduna urban area, North Central Nigeria and is located on latitude 10°28' North and longitude 7°25' East. Rainfall is characterized by seasonality of wet and dry seasons determined by the duration of the interplay of the dominant two air masses (Wet tropical maritime and the dry continental air masses). Average rainfall receives in the area is 750 mm per annum and is concentrated in 6 months of rainfall (May to September). The area is drained by a number of rivers, streams and man-made drains among which are Kaduna, Kangimi, Romi and Rijase rivers.

There are additionally, several man-made drains, initially constructed to manage urban storm runoff and have been converted to municipal wastewater and industrial effluents disposal conduits such as Kawa, Golf course, Bundum-bundum Sardauna Crescent, Tudun wada, Abattoir, Barnawa, Abakpa, Kakuri, Makera and Rafin Dai drains. Irrigation is popular in the area along the rivers, streams and the man-made drains producing the town's requirements in garden crops and providing

employment to hundreds of urban dwellers in the area. The study was restricted to irrigated fields along drains fed by wastewaters from industrial and domestic operations and was carried out in the month of January 2005 when irrigation activities were at a peak. Data was obtained mainly from primary sources through the administration of questionnaires and focused group discussions. Purposeful random sampling technique was employed by this study so as to obtain information mainly from farmers practicing irrigation in the area from which wastewater is used.

About 200 questionnaires were administered to 200 respondents; the responses were collated in tabular forms and by use of descriptive statistics which are percentage and average bias, the results were analyzed. Data from secondary sources on wastewater and soil physico-chemical parameters were obtained so as to observe the effect of wastewater use on the soil and consequently on the crops produced.

RESULTS AND DISCUSSION

Results of analyses as shown in Table 1 gives reasons for farmers' utilization of wastewaters in drains for irrigation. Table 1 shows that 54% of the farmers were of the view that the use of wastewater in drains for irrigation is due to its reliability in supply. About 30% posit that the use of wastewater for irrigation requires less application of chemical fertilizers while a few, however are of the opinion that the attractive nature of wastewater and the lack of alternative source are responsible in the use of wastewater for irrigation in the area.

This agrees with the view expressed by Buechler and Devi (2003) that irrigation with wastewater provides steady water supply and may eliminate fertilizer application. This implies that water which is required for irrigating crops and also to improve crops performances under field capacity is met. Low application of chemical fertilizers indicates that wastewater contain some nutrients beneficial for plants developmental processes, hence boosting crop production at minimal cost.

Suitability of wastewater for irrigation as presented on Table 2 shows that all the farmers interviewed agree that wastewater in the area in one way or the other is suitable for irrigation. The levels of suitability, however differ. Most of the farmers express the view that wastewater as found in drains are suitable when applied on agricultural lands as in irrigation. About 20% each agree that wastewater is either highly or slightly suitable. The availability of water in the drainage system throughout the irrigation period is one of the reason advanced by most farmers for considering the water as suitable.

Table 1: Farmers reasons for use of wastewaters in drains for irrigation

Reasons	Percentage
Water is available constantly	54
Water is attractive in appearance	10
Water when used requires less application of chemical fertilizer	30
There is no alternative source of water	6

Field work (2005)

Table 2: Suitability of wastewater for irrigation as perceived by farmers

Suitability	Percentage
Highly suitable	20
Suitable	60
Slightly suitable	20
Not suitable	0

Field work (2004)

Table 3: Problems observed by farmers in the use of wastewater for irrigation

Problems	Severe (%)	Slightly severe (%)	Not severe (%)
Leaf burn on some crops	10	30	60
Water logging condition	_	40	60
Low crop yields	_	20	80
Crops taste differently		60	40

Field work (2004)

However, many indicated that should there be alternative sources of water they might provide better options, i.e., fresh water from streams, piped borne and underground aquifers. This finding agrees with the study carried out by the UNDP (1978) which stated that farmers' use of wastewater for irrigation in the area is due to no alternative and that farmers have to be contented with what is available.

Table 3 shows problems, associated to the use of wastewater for irrigation, most of the problems are in relation to crops performances. The greatest problem, the farmers expressed as observed in the use of wastewater for irrigation is leaf burn on some crops with 10% being severe and 30% slightly severe.

All other respondents are of the view that other problems such as waterlogging condition, low crop yields and crops taste differently from those on which fresh water is used are slightly severe. Though, most respondents posit that problems are slightly severe however, 60% agree that the taste of some crops is affected by the quality of water used in irrigation. Samaila observed that high amounts of total dissolved solids are likely to interfere with normal developmental processes of most crops and that where sodium concentration is high in the irrigation water internal drainage is impeded and is likely to cause waterlogged soil conditions.

The implication of these on crops is that taste of some crops are affected and that some harmful substances in the wastewater may concentrate at intensities likely to magnify within the food chain in such a manner to result in serous health problems to both producers and consumers of such crops. Though, wastewater offers a most dependable source of irrigation water it is not without consequences on both the soils and crops and it

is in this respect that Samaila suggested that caution most be observed in the reuse of wastewater for irrigation, especially on highly sensitive crops. Table 4 shows the impression of farmers on the tolerance and sensitivity of irrigated crops to wastewater application. Industrial effluents seem to affect most garden crops which are highly sensitive. Only but few crops observed by the farmers are tolerant to industrial wastewater and are such crops with longer harvesting periods sometimes extending into the raining season. Most crops, produced by farmers in the area however, indicate tolerance to domestic wastewater.

Wastewaters from both industrial and domestic processes are sensitive to most garden crops implying that there is need for proper management of the wastewaters when applying on these crops. Samaila suggested that where crops are to be eaten raw or are partially boiled, they should not be irrigated with wastewater and even where crops are tolerant there should be time lag between harvesting period and water application.

Farmers' adaptation to wastewater irrigation is shown in Table 5. This shows some of the management strategies employed by farmers in the area to overcome problems associated to wastewater reuse. Selection of crops to grow on the irrigated farm plots is popular to 60% of the respondents while increase in the frequency of irrigation water is practicable to all the farmers. The non-availability of fresh water in the drainage system, particularly in streams and drains accounted for the low acceptance of dilution of wastewater with freshwater as a management strategy and is not practicable by 100% of the respondents. About 40% of respondents expressed observing nature of wastewater on recipient surfaces before its application in irrigation.

This is done to avoid wastewater that may pose severe consequences to the development of crops. This implies that safe periods exist during production processes at which the application of wastewater for irrigation may not be accompanied by serious after effects. Table 6 shows the physico-chemical properties of wastewaters and soils on irrigated fields in Kaduna township. This shows the quality of wastewater and soils in the area.

The level of concentration of the chemical parameters indicates that wastewater in the area has high amounts of substances at intensities likely to be injurious to normal crops requirements. The high concentration of total salts as shown by the electrical conductivity is a pointer to high salt content which when applied for irrigation development may inhibit the transmission of water into the plant (a necessary requirement for plants developmental processes), thus affecting the osmotic ability to absorb water by the growing plants. High concentration of salts will gradually be accompanied by salinity built-up in the soil as indicted by the soils under irrigation in the area.

The presence of essential elements in appreciable concentration such as phosphates, nitrates, magnesium, calcium and potassium may ameliorate soil nutrients availability and improve internal structure for example, it has been observed that increase in magnesium and calcium concentrations improve soil internal structure by counteracting poor internal drainage caused by over concentration of sodium ions. Essential elements of plants nutritive value means increase in soil fertility indicating that application of additive in form of chemical fertilizers may not be necessary. Though, pH of

Table 4: Crops tolerance and sensitivity to wastewater

Crops response	Domestic sewage	Industrial effluents
Highly sensitive	-	Onions, tomatoes, garden eggs, spinach and most garden perishable crops
Sensitive	Onions, cucumber, cabbage and okra	-
Highly tolerant	Sugar cane, maize and cassava	-
Tolerant		Sugar cane and maize

Table 5: Farmers' adaptation to wastewater irrigation

Adaptation	Practicable (%)	Not Practicable (%)
Selection of crops to grow	60	40
Increase in the frequency of irrigation water	100	0
Dilution of wastewater with fresh water	0	100
Observance of nature of wastewater on recipient surfaces	40	60

Field work (2004)

Table 6: Physico-chemical properties of wastewater and soils on irrigated fields in Kaduna town

Sites/wastewater	NO_3	TDS	pH	Cl	PO_3	Mg	Ca	K	Pb	B	Na	SAR	EC
Makera	0.80	1578	7.70	920.4	9.90	26.8	25.6	5.90	0.07	0.16	156.0	6.70	2254
Kakuri	2.28	678	7.40	435.0	4.60	26.0	79.3	3.50	0.07	0.16	57.6	2.30	969
Kudenda	0.40	548	8.90	46.2	3.00	28.5	25.1	3.80	0.08	0.16	148.8	6.70	834
R. Kaduna	0.30	95	7.50	125.0	1.70	34.1	10.2	0.80	0.08	0.12	8.2	0.40	135
Textiles	0.45	2460	9.44	1350.0	16.75	23.4	26.6	6.25	0.05	0.16	216.0	8.50	3515
Petrochemicals	3.40	380	4.70	113.0	5.80	26.0	76.0	0.60	0.12	0.16	8.6	0.35	545
Breweries	0.90	590	7.50	42.5	7.50	23.0	36.6	3.50	0.08	0.16	103.0	9.10	849
Soils	-	-	6.89	-	3.90	0.3	0.9	0.45	-	-	1.3	-	424

Wastewater: Cations/anions in milli grams. Soils: Units in milli equivalents 100/g of soil; EC: Electrical Conductivity (micromhos)

Table 7: Guidelines for interpretation of chemical quality of irrigation water

	Degree of problem		
Irrigation problem	No problem	Increasing problem	Severe problem
Salinity (EC ms cm^{-1})	0.75	0.75-3.0	3.0
Ion toxicity			
Sodium, SAR	3.0	3.0-9.0	9.0
Boron (mg L^{-1})	0.75	0.75-2.0	2.0
Chloride (me L^{-1})	4.0	4.0-10	10.0
pH	Normal range	6.6-8.4	
Nitrates (mg L^{-1})	5	5.0-30	30.0
Bicarbonates (me L^{-1})	1.5	1.5-8.5	8.8

Ayers and Westcots, 1976

most wastewaters in the area fall within the acceptable limit considered safe for irrigation however, caution must be observed in the use of wastewaters from Kudenda, textiles and petrochemicals whose reuse is likely to be accompanied by serious after effects. Comparing Table 6 to 7, it is obvious that some of the chemical properties are concentrated at intensities above the recommended levels considered safe for wastewater usage for irrigation development. Total salts concentration as expressed by total dissolved solids and electrical conductivity of wastewater is above the safe limit considered for irrigation.

The implication in the use of such water on farm plots is that it may lead to salinity built-up in the soil which will affect the osmotic pressure of most crops thus affecting their productive potentials. Sodium adsorption ratio for most waters fall >3 considered suitable with no degree of problem. This indicates that using water from these sources will result to sodium accumulation in the soil that may impede internal drainage and leading to water-logged soil condition. Such a condition does not favour the growth processes of most crops.

The concentration of chloride is high for water in Makera, Kakuri and textiles, the presence of this in irrigation water may cause leaf burnt in some plants thus interfering with the normal developmental processes.

CONCLUSION

In most urban industrial centers in Nigeria, wastes are produced both from industrial and domestic processes. Most of these wastes contain both organic and inorganic by-products that may concentrate at levels and intensities likely to affect environmental systems. Wastes whether solid, gaseous or liquid end up into the drainage system to pollute surface water receiving sources. The presence of pollutants affects water quality and reduces it potential uses. Irrigation requires least water quality standards, thus affords the opportunity to manage wastewater with minimal adverse environmental effects. Though, the reuse of wastewater for irrigation is popular with most farmers in Kaduna, this study however, reveals that the concentration of certain ions are above the threshold level considered safe for irrigation and that caution must be observed in the use of water in the area for irrigation. The high level concentration of sodium, total salts and chlorides in water is a serious limitation in the use of water for crop development in the area. The use of wastewater for irrigation as a management strategy in most urban industrial areas in Nigeria should be reviewed as this study shows that such management poses serious risks to both producers and the consumers of the crops from this practice

RECOMMENDATIONS

To reuse wastewater for irrigation with minimal environmental and human health consequences, the following recommendations are proffered. Wastewater should undergo some form of treatment to reduce the lethal concentration of ionic concentrates in the process water before its release into surface receiving sources. Monitoring units should be installed in agricultural extension services so as to ensure wastes in water conform to standards recommended for irrigation. Enlightenment campaigns should be organized to educate the farmers on the safe ways of utilizing water in the area for irrigation development.

Alternative sources of water should be made available to farmers so as to practice irrigation with minimal environmental consequences. Alternative sources of wastewater disposal mediums should be explored such as deflocculating tanks and subsoil disposal instead of the free use of the open drainage system.

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