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THE INFLUENCE OF WASTEWATER ON SOIL CHEMICAL PROPERTIES ON IRRIGATED FIELDS IN KADUNA SOUTH TOWNSHIP, NORTH CENTRAL NIGERIA

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ABSTRACT

The study examines the influence of wastewater irrigation on soil chemical properties in Kaduna South Metropolis. Sixteen water and fifteen soil samples were collected from drains and from irrigated fields. The samples were subjected to laboratory analyses to determine properties related to sodicity, salinity and toxicity. The result of analyses showed that the greatest problem faced withy most soils in the area is that of salinity built up (121 – 1273 micromhos) which in turn affects negatively their productive capacity for plant development. The low nutrients availability in the soils as revealed by this study can be ameliorated by wastewater application rich in ionic nutrient elements such as, phosphates, nitrates, calcium, magnesium and potassium. Proper management practices such as partial treatment of wastewater before its discharge into water recipient surfaces, the selection of tolerant crops, awareness campaigns on the danger in the direct use of untreated water for crop development and monitoring of the quality of surface water applied in irrigation should form integral components in agricultural development schemes for urban and peri-urban industrial centers.

Keywords: wastewater, irrigation, sodicity, salinity and pollutants.

INTRODUCTION

The management of wastewater in most urban areas is a serious environmental problem that has defied most possible solutions of both policy makers and environmental planners especially in the developing countries. The disposal of wastewater into open drains, canals and streams, is not only damaging but a worst threat to human health and marine biodiversity. The re-use of wastewater for irrigation therefore offers a very promising water conservation alternative. Feachem, McGarry and Mara (1982) were of the view that the use of wastewater for irrigation often allows the free discharge of wastewater. The disposal of wastewater on land presents not only an appropriate medium for disposal of many wastes but can be a cheaper way of waste treatment. This is because treatment prior to re-use of wastewater on land can be expensive and technically complex while on the other hand will provide subsequent treatment and recycling if wastewater is discharged on it. Loehr (1977) observed that elements considered as pollutants in water are necessary in some desired quantities for all living organisms. In support to this Hamsen, Israelson and Stringham (1980) posits that not only is small amounts of salts in water are harmless but also stimulate the growth of crops under some condition. However, excessive concentration of substances as commonly exhibited by most wastewater when applied for irrigation may lead to potential built up of harmful elements in the soil, which in turn will affect its productive capacity.

Many research workers have documented that the re-use of wastewater for irrigation has the advantage of recycling and enriching the soil with nutrients (Prescod, 1992 ; Musa, Yaji. and Haque (1993) ; Downs Cifuetus, Ruth, and Suffet (2000) ; Hussein., Raschid., HanjiraI., Marikar. and Van der Hoek (2001).; Okpala, 2002 ; Samaila 2005). Musa et al (1993) have observed that the re-use of wastewater for irrigation is advantageous as it contains some valuable plant nutrients. Others have however stated that the re-use of wastewater for irrigation could result into accumulation of harmful ionic substances in the soil at chronic levels likely to be injurious to normal crop developmental processes ; Cui., Zhai ,Chen and Huang (2004), Singha, Gupta, Bhatt, Pandey, Rai and Singh,(2006) ; Sharma, Agrawal, and Marshal (2007). It has also been observed that large scale and long term application of wastewater on soils may lead to danger of insect infestation, pollution of groundwater and built up of metals, salts and other toxicants (Maddady and Gbasemi 2001, Matos, Fontes, da Costa and Martinez (2001),Samaila 2005 and Sharma et al 2007).

The re-use of wastewaters from either domestic or industrial processes for irrigation is a common phenomenon of most urban industrial centers of the world. In Pakistan for example farmers were able to grow high quality crops like vegetables with wastewater (van der Hoek et. al. 2002). The diversion of wastewater from drains and or canals into irrigated fields may result into accumulation of harmful substances in the soil root zone at intensities and levels likely to impair and degrade the soil and result into health hazards. Wastewater when used directly for irrigation can increase the quantities of solutes thereby raising the concentration of certain ions and eventually lowering the quality of the water for irrigation (Ayers and Westcots, 1985). The major constrains to the use of wastewater for irrigation are the issues of environmental pollution, soil degradation and health hazards posed to both the farmers and consumers of the irrigated crops and evidences of many completed researches abound on these issues for many areas of the world. Reports from many studies have shown that large scale and long term application of wastewater on the soil may lead to danger of insect infestation, pollution of groundwater and built up of heavy metals, salts and other toxicants in the soil (Hussein et al 2001, Okpala 2002, Samaila 2005 and Sharma et al 2007).

Kaduna is one of the most industrialized urban centers in Nigeria. The town has a very long history, being the capital of Northern Nigeria since early 20th century and now of Kaduna state since 1976. Several industries were established in the town with many dating back to the 1940s and 1950s. Many of the machineries in these industries are old and emit oily substances as they operate. In addition, effective wastewater treatment facilities are lacking in most of the industries. Consequently, effluents are being discharged freely into drains that connect the industries to the main drainage network (the (Kaduna river) in the town. Past research works in the area have concentrated mainly on the impact of wastewater discharge on surface and underground water quality (Kemdirim 2005, Samaila 1996 and Samaila 2005). Since the water in streams of the Kaduna River is being used for crops cultivation there is every basis to be concerned about possible built up of toxic substances in the soils of the area, which could lead to health hazards. Studies are thus needed that examine the extent of this accumulation in the area.

The objective of this paper therefore is to examine the influence of wastewater application on chemical conditioning of irrigated soils in Kaduna urban area, Nigeria.

METHODOLOGY

Kaduna State lies between Latitude 090 00 – 110 00' and longitude 060 05'- 8 50'. The State occupies an area of about 45, 567 sq km. The state capital Kaduna town lies on latitude 100 28' north and longitude 7o 25' east.

The town experiences the tropical humid continental type of climate characterized by seasonality. The area is well within the northern limits of the movement of the Inter Tropical Convergence Zone (ITCZ). This phenomenon of the global circulation of air masses is responsible for the general climatic characteristics. The onset of raining season starts from late March and ceases in mid October, paving way for the dry season, which starts from late October to early March.

The study is restricted to the Southern part of Kaduna metropolis, where most industries are sited and wastewaters from both industrial and domestic processes find their way into the drainage system and eventually are used on irrigated farm plots to produce the town needs in garden crops, particularly in the dry season. The study therefore covers Makera, Kakuri and Kudenda industrial axis.

Sample Collection

To evaluate the effect of wastewaters on soil properties, both soil and water samples were taken on the field for laboratory analyses. Water samples were taken from both the streams and drains that receive wastewaters. Sixteen water and fifteen soil samples from four main locations namely Makera, Kakuri, River Kaduna and Rafin Dai drains and on irrigated fields in Kaduna South Township were considered (see figure 1). Soil samples were taken from the cultivated farmlands receiving wastewaters.

Water samples were collected from three sources namely industrial effluent outlets, wastewater in drains and River Kaduna. In determining the sampling points care was taken in deciding at what points problems exist and where mixing is adequate to allow taking representative samples. Samples were collected in 500mls thoroughly cleaned plastic bottles, treated with 3 to 4mls of nitric acid, firmly closed and stored in a refrigerator at temperature of 3 to 4oC to preserve them.

Fifteen soil samples were also collected on irrigated fields in Makera, Kakuri and Kudenda by use of the free traverse method, so as to allow flexibility in the choice of the sampling points.

Samples Analyses

Both soil and water samples were subjected to laboratory analyses to determine chemical properties associated to salinity, sodicity and toxicity so as to be able to relate concentration of substances in water to that of the soil.

The collected soil samples were analysed for pH using a pH digital meter, electrical conductivity by use of portable conductivity meter, particle size analysis by hydrometer method, total phosphorus by ignition 0.2NH2SO4 extraction method, total nitrogen percent by Macro Kjedhal method while exchangeable cations were obtained by ammonium acetate leaching method.

For the Water samples pH and electrical conductivity were determined using the same procedures as in soil samples. On the other hand, ascorbic acid method was used for phosphate while calcium and magnesium levels were determined by EDTA titrimetric method. Oven dry method was used for total dissolved solids. Sodium and potassium were determined by flame emission photometric method while boron and lead were by atomic absorption spectrometric method and nitrates by ultra-violet spectrophotometric screening.

RESULTS AND DISCUSSIONS

Texture; The textural class of the soils on irrigated fields in the study area is that of sandy loams and this finding agrees with that obtained by the Kaduna Sewerage and Drainage Project (1978). A close look at table 1 reveals clearly that there is very little variation in the textural characteristics of the soils over the five sampling locations. A possible reason for this is the sameness on the geological parent material over the Kaduna river basin.

Table 1: Particle Size Analysis of Soils in Kaduna South

Locations	Sand %	Silt %	Clay %
Makera	66.03	24.26	9.71
Kakuri	60.03	27.60	12.37
Kudenda	66.03	20.93	13.06
Nasarawa	60.03	26.26	13.71
Along R. Kaduna	66.69	20.94	12.37
Mean	63.76	20.00	12.27

Source: Field and laboratory analysis (2005)

Chemical Properties

Table 2 gives some of the chemical properties of soil samples analysed. The pH values range from 6.62 to 7.28 and with a mean of 6.89. Kodiya (1988) recorded a mean pH value of 8.5 for the South Chad project while Afshin et. al. (2007) recorded a decrease in soil pH with depth where wastewater is used in irrigation. The pH values observed for the area fall within the range of pH recorded for most top soils in the West African Savannah and it is within the range considered suitable for irrigation..

The concentration of total salts as indicated by electrical conductivity of soil extracts is highest for soils in Makera recording 1273 micromhos and Kudenda with lowest of 121 micromhos. The application of wastewater in Makera drain fed by untreated textile effluents for irrigation, inability to leach excess salts due to low water application rates and high evaporation may be responsible for high amounts of total salts observed for the area. Tivy (1990) observed that soils of electrical conductivity above 400 micromhos tend towards salinity. For all soil sampled, only Makera is above 400 micromhos, the concentration of salts in soils along river Kaduna and Kakuri indicate that should wastewater be used continuously for irrigation without proper management salinity may be raised to toxic level in the soils.

Table 2: Mean Concentrations of Chemical Properties in Kaduna South Soils

	Soil pH	Ca me/100g	Mg me/100g	K me/100g	Na me/100g	N %	PO_4 Mg/L	CEC %	Base Sat. %	Na Abs. Ratio (SAR)	Elect. Cond. (EC)
Makera	6.62	1.5	0.6	0.2	1.5	0.02	4.6	60	6	2.07	1273
Kakuri	7.17	1.02	0.2	0.1	1.0	0.014	5.0	39.2	6	1.78	242
Along R. Kad.	7.20	0.5	0.2	0.4	0.9	0.04	1.3	36.8	4	2.4	121
Mean	7.28	0.8	0.3	0.1	1.4	0.014	4.1	56	5	6.67	303
	6.89	0.9	0.3	0.2	1.3	0.18	3.9	52.2	5.25	2.46	424

Source: Field and laboratory analysis, (2005)

The concentration of exchangeable cations was generally low for the soils. The mean calcium and magnesium concentrations were 1.2 me/100 grams of soils and a standard deviation of 0.54. The mean concentration of potassium was 0.2 me/100 grams of soil and sodium had a mean concentration of 1.3 me/100 grams of soil. The Kaduna Sewerage and Drainage Project (1978) also recorded very low concentration of exchangeable cations in Kaduna South soils (0.75 – 3.76 me/100 grams of soil for calcium, 0.28 – 0.30 me/100 grams of soils for potassium and 0.36 – 0.90 me/100 grams of soil for sodium). Sodium ion is slightly higher to that of other cations in the soil which can be attributed to in part, the application of sodium rich textile effluents for irrigation and the precipitation of ions of calcium and magnesium in the soil and their replacement with sodium ion.

Cation Exchange Capacity ranges from 36.8% in Kudenda to 60% in Makera soils. The mean cation exchange capacity of 52.2% is moderately high. Kodiya (1988) also observed a similar trend in the cation exchange capacity of irrigated soils in the South Chad Project. The high cation exchange capacity recorded for the area may be attributed to the clay type, humus content and also the presence of nutrients in wastewater used for irrigation. See table 3.

Table 3: Mean Concentration of Cations and Bicarbonates in Kaduna South Wastewaters (me\l)

	Makera	Kakuri	Rafin Dai	R. Kaduna
Sodium	6.8	2.5	5.3	0.4
Magnesium	2.2	2.1	2.3	2.8
Calcium	1.3	4.0	1.2	0.5
Potassium	0.14	0.09	0.1	0.02
Bicarbonates	0.03	0.03	0.04	0.06
SAR	6.6	2.3	6.7	0.40
Permeability index	11.2	5.3	11.4	2.7

Source: Fieldwork and laboratory analyses, (2005) The mean nitrogen percent was 0.018 and ranges from 0.014 to 0.021. For soils of Kadawa irrigation Scheme Essiet (1987) recorded a total nitrogen percent of 0.03 pre-irrigation and 0.04 post irrigation periods. The result obtained for nitrogen percent is low like in many West African soils. Low nitrogen percent observed for the area may be attributed to the farming system, which involves the removal on farm plots crop residues for domestic purposes and the burning of whatever is left during farm clearance.

Mean phosphorus concentration was 3.9me/100 gram of soil. Phosphorus concentration was generally low compared to the 243.00ppm recorded for the Kadawa soils (Essiet, 1987). The low phosphorus observed might be due to over cropping which tends to remove too much nutrients from the soils, low application of phosphorus rich fertilizers and the leaching of the nutrient from the soil root zone.

Suitability assessment of soils for wastewater irrigation in Kaduna South Metropolis

The mean PH values for wastewater in most drains (7.7) fall within the pH 6.6 – 8.4 suitable for irrigation under most conditions (Ayers and Westcots, 1985). The present level of soil pH (6.89) poses no problem for use of wastewater in the area for irrigation development. However, the wastewater in Rafin Dai drain (pH 8.89) and textile industries (pH 9.5) as shown in table 4, fall above the permissible limit considered safe for irrigation water, which indicate that caution most be observed in the use of water from these sources for irrigation as this may be accompanied by serious after effects on the soil. High pH values indicate alkalinity problem with sodium ion likely to be the dominant cation in the soil colloid, which can lead to flocculating soil condition, decline in aeration and poor internal drainage, resulting in water logging, thus affecting normal plant developmental processes.

Table 4: Concentration of Chemical Properties in Kaduna South Wastewaters

SOURCE OF WATER	EC micromhos	Water pH	Cl mg/L	HCO_3 Mg/L	PO_3 mg/L	NO_3 mg/L
River Kaduna	135	7.5	125	3.8	1.7	0.3
Makera Drain	2254	7.7	920	2.1	9.9	0.8
Kakuri Drain	969	7.4	435	2.0	4.6	2.28
Rafin Dai Drain	834	8.9	46.2	2.3	3.0	0.4
Textile/Garments	35.5	9.5	1358	3.0	16.8	0.45
Petro-chemical	595	4.7	113	1.5	5.8	3.4
Foods, Drinks and Beverages	849	7.5	42.5	2.0	7.5	0.9

Source: Field and Laboratory Analysis, (2005)

Salinity: The electrical conductivity of wastewater as presented in table 4 is above the 750 micromhos considered suitable for irrigation under most conditions (Ayers and Westcots, 1985). The mean electrical conductivity of soil extracts shows that soils fall within 400 micromhos considered for saline soils. The prolonged use of wastewaters in the area for irrigation will gradually be accompanied by salinity built up in the soils especially when proper management is not adopted. The particle size analysis, has however, shown that the soils made up of sandy loams are better drained and so can withstand wastewater application, especially, with proper management practices such as increase in frequency of application of irrigation water, selection of tolerant crops and the partial treatment of wastewater from source. Feachem etal (1982) observed that good drainage and proper management would lower the contact period between the plant and saline waters. The lethal concentration of total salts in irrigation water will result in soil salinisation, which in turn may raise the osmotic pressure of the soil and so prevents the absorption of water by plants. Table 5 gives crops response to soil salinity and indicates that yields of many crops are restricted by high levels of total salts.

Table 5: Crops Response to Soil Salinity

Electrical conductivity of soil extract micromhos/cm at 25^{o}C	Crop response
0 – 200	Largely negligible
200 – 400	Yields of sensitive crop may be restricted
400 – 800	Yields of many crops restricted
800 – 1600	Only salt tolerant crops
Above 1600	Very few tolerant crops

Source: Tivy, 1990.

Sodicity: The effect of sodium depends on the relative presence of other cations in the soil. The mean sodium concentration is slightly higher to that of calcium and magnesium. High amounts of sodium ions can result in the precipitation of calcium and magnesium ions from the soil thus affecting their effectiveness in enhancing physical internal drainage. An increase in the proportion of sodium as indicated by wastewaters in drains will promote higher levels of soil alkalinity. Sodium Absorption Ratio of the soil extracts fall below 3 considered suitable (Ayers and Westcots, 1985) and with no degree of problem. The re-use of wastewater in drains in the area for irrigation may gradually be followed by adverse sodicity problems. The implication on the soil and plants is that it will have marked influence on permeability, resulting in a soil with poor internal drainage thus affecting infiltration of water and retards plant growth. High amounts of total salts as indicated by electrical conductivity of the area can help to improve soil structure by the deflocculating action which, tends to counter the poor physical condition caused by high sodium concentration in the soil. Table 6 gives the sodium absorption ratio and electrical conductivity of soil extracts.

Table 6: Sodium Absorption Ratio and Electrical Conductivity of Soil Extracts in Kaduna South.

Location Sodium absorption Ratio (SAR) Electrical Conductivity (EC micromhos)

Location	Sodium absorption Ratio (SAR)	Electrical Conductivity (EC micromhos)
Makera	2.07	1273
Kakuri	1.78	242
Kudenda	3.62	121
Nasarawa	2.14	303
Along R. Kad.	2.67	181
Mean	2.46	424

Source: Field and Laboratory analyses, (2005)

Cation Exchange Capacity: As shown in table 2 the cation exchange capacity is moderate in its distribution. The implication is that it indicates the presence of appreciable amounts of nutrients thus improving the retention capacity of the soil in the area, which is adequate for plants. Kudenda and Kakuri record low cation exchange capacity of 36.8 and 39.2 respectively. Low cation exchange capacity has serious implication, under continuous cropping nutrient deficiencies are bound to occur. The supply of nutrients as present in wastewater will be of advantage by raising soil fertility and enhancing plants growth in the area.

Toxicity: Boron toxicity is generally low in wastewaters of the area. Urroz (1976) observed that boron concentration of o.4mg/L is suitable even for highly sensitive crops. All values of boron for Kaduna South wastewaters fall below 0.4mg/L indicating that boron poses no problem for irrigation water in the area.

Chloride is high in textile effluents (1350mg/L) Makera drain served by textile effluents (920mg/L) and Kakuri drain (435mg/L). Chloride is toxic to crops growth when present in the soil at high concentration. The concentration of chloride at about 700 – 1000mg/L causes leaf burn in fruit crops (Baver etal, 1972). Low nitrogen % observed for soils indicates that they are deficient in nitrogen and requires replenishment by application of organic fertilizers and chemical additives rich in nitrogen.

RECOMMENDATIONS

The following recommendations if properly observed will provide guides for wastewater management in most urban centres.

1. There is the need for both government and private enterprises to be actively involved in wastewater treatment from source before its being discharged into surface receiving bodies.
2. There should be continuous monitoring of wastewaters both from industrial and domestic processes as this will help in ensuring the maintenance of proper quality standards.
3. The disposal of wastewater on surface receiving sources is grossly inadequate. The disposal of wastewater on non-detrimental sites and non-residential areas should be preferred.

4. Substances used during production processes should be separated from water for other productive purposes and the water re-cycled without causing injury to the environment.
5. There is need for establishing quality standards for wastewater disposal. There should be strict supervision of compliance by FEPA.
6. Detail researches on the reactions and transformations, which occur in soils when wastewater is applied for irrigation, should be conducted so as to evaluate the suitability of wastewater for irrigation development.

CONCLUSION

The re-use of wastewater for irrigation in most urban areas in Nigeria has increased food supply and the per-capita income of a portion of urban population. Wastewater when applied on agricultural lands offers a cheaper and a more feasible alternative medium for wastewater management. The utilization of poor quality water for irrigation may however raise the concentration of ionic substances to chronic levels thus affecting the productive capacity of the soil.

There is the predisposition for soils to become saline by the re-use of salt rich wastewater for irrigation. For successful application of wastewater for irrigation there is need for proper management practices which include selection of tolerant crops, treatment of wastewater prior to its re-use for irrigation, liming of sodic soils and the increase in the frequency in application rates of irrigation water, to leach excess salts. The study has shown that wastewater with appreciable concentration of ionic substances and at tolerable limits enriches the soils with nutrients required for plants developmental processes and is the source from which water is available especially during the dry season for irrigation development.

REFERENCES

Ahmed K. and Tanko A. I (1994).Quality Hazards in Water for irrigation at the Kano River Project Phase 1 KRPPI) Journal of the Social and Management Studies Vol. 1. NO 2 pp 12-19.

Al-Nakshabandi G. A., Saqqar M. M., Shatanawi M. R., Fayyas M. and Al-Horani H. (1997). Some Environmental Problems Associated with the use of Treated Wastewater for Irrigation in Jordan. Agricultural Water Management 34; 97

Ayers R. S and Westcots D. W (1985).Water Quality for Agriculture. Irrigation and Drainage Paper 29 Rev. 1 (FAO), Rome.

Baver L. D, Gardner W.H and Gardner W.R. (1972).Soil Physics. Fourth Edition Wiley and sons, New York.

Cui Y. J., Zhu Y. G., Zhai R. H., Chen D. y. and Huang Y. Z. (2004).Transfer of Metals from Soil to Vegetables in an Area near a Smelter in Nanning, China, Environmental International No. 30 pp 785-791.

Downs T. J., Cifuetus E., Ruth E. and Suffet I. (2000).Effectiveness of Natural Treatment in a Wastewater Irrigation District of the Mexico City Region. A Synoptic Field Survey. Water Environ.Res. Vol. 72 pp 4-21.

Essiet E. U. (1987).Monitoring Soil Water quality in Agricultural Development Projects in Nigeria. In Mortiomore et al(eds) Perspective on Land Administration and Development . Department of Geography Bayero University Kano, Nigeria.

Feachem R. McGarry M. and Mara D. (1982).Water, Wastes and Health in Hot climates John Wiley and Sons U. S. A.

Hamsen V. E, Israelson O. W and Stringham G. E. (1980).Irrigation Principles and Water Practices. John Wiley and Sons, New York.

Hussein I., Raschid L., Hanjira M. I., Marikar F. and Van der Hoek W. (2001). A Framework for Analyzing Socio-economic, Health and Environmental Impacts of Wastewater use in Agriculture in Developing Countries Working Paper 26, Colombia; International Water Management Institute (IWMI).

Kaduna Sewarage and Drainage Project (1978). Project Master Plan Annex C. Technical Studies.

Kemdirim E. C.(2005).Studies on the Hydrochemistry of Kangimi Reservoir, Kaduna State, Nigeria. African Journal of Ecology, Vol 43 pp 7-13.

Kodiya A. (1988).Effects of Irrigation on Some Soil Characteristics in the South Chad Project Area Maiduguri, Nigeria. An Unpublished M. Sc. Thesis. Beyero University Kano, Nigeria.

Loehr R. C. (1977).Pollution Control for Agriculture Academic Press Inc. New York.

Maddady M. and Gbesemi A. (2001).The Study of Pollution in Shiraz plain: Open University. In Farsi.

Matos A. T., Fontes M. P. F., da Costa L. M. and Martinez M. A. (2001). Mobility of Heavy Metals as Related to Soil Chemical and Mineralogical Characteristics of Brazilian Soils. Environmental Pollution iii.

.Madyiwa,S;Chimbari,M;Nyamangara,J. and Bungaria,C.(2002).Cumulative effects of sewage sludge and effluent mixture application on soil properties of a sandy soil under mixture of star and Kikuya grasses in Zimbabwe; Physics and Chemistry of the Earth. No. 24 pp 747-753.

Musa S. M Yaji M. and Haque M. A. (1993).The use of Wastewater for Irrigated Onion. Nigeria Journal of Water Resources Vol 1 No. 2 pp 19-24.

Ogbalor B. (1991).An Evaluation of Domestic Wastewater Quality for Irrigation of Vegetable Crops Along the Jakara Stream, Kano, Nigeria. An Unpublished M. Sc. Thesis Bayero University Kano, Nigeria.

Ogezi A. E (1990).Impact of Mining on the Nigerian Environment. In Aina E. O and Adedipe N. O(eds),FEPA Monograph 2, Towards Industrial Pollution Abatement in Nigeria; FEPA, Lagos.

Okpala,C.I.(2002).Urbanization,Poverty and Urban Food Security in Urban Agriculture Magazine,Wolrd Summit Special:ETC-Netherlands Resource Centre for Urban Agriculture and Forestry.

Samaila K. I (1996). The Influence of Industrial Liquid Wastes on Water Quality for Irrigation in Kaduna South. An Unpublished M. Sc. Thesis Bayero University Kano, Nigeria.

Samaila K. I. (2005). The influence of industrial effluents on water quality for irrigation in in Kakuri, Makera and Kudenda industrial axis of Kaduna south township, Nigeria. Nasarawa Scientifique; A journal of Natural and Applied Sciences Vol. 1 No. 2 pp 12-21.

Sharma,R.K.,Agrawal,M. and Marshall,F.(2007).Heavy metal contamination of soil and vegetables in suburban areas of Varomsi,India. Ecotoxicology and Environmental Safety No.66 pp 258-266

Singha,S.;Gupta,A.K;Bhatt,K.;Pandey,K;Rai,U.N. andf Singh,K.P.(2006).Distribution of metals in the edible plants grown at Jajmau,Kampur(India) receiving treated tannery wastw water:Relation with Physico-chemical properties of the Soil. Environmental Monitoring and Assessment, No.115 pp 1-22.

Tivy J. (1990).Agricultural Ecology, Longman Singapore.

Urroz E. (1976.Re-utilisation of Residual water and its effect on Agriculture. ICID 1976, SYMPOSIUM.

Van der Hock,W.(2004).A framework for global assessment of the extent of wastewater irrigation. The need for a common wastewater typology.In Scott,C.A.Faruqui,L and Raschid,S.(eds.) Wastewater use in irrigated agriculture:Confronting the livelihood and environmental realities;Walling Ford,U.K.CABI publishing.

Whipple W. (1977). Planning of Water Quality Systems Lexinton Books.

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