JASEM ISSN 1119-8362

Full-text Available Online at
www.ajol.info and
www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage. *Sept*, 2011
Vol. 15 (3) 431 - 437

Quality Evaluation of Household Wastewater for Irrigation

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ABSTRACT: Water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development. Irrigated agriculture occupies approximately 17 percent of the world's total food production. Whenever good quality water is scarce, water of marginal quality will have to be considered for use in agriculture. Domestic wastewater varies in composition from place to place due to different water sources used and also the composition and soil minerals from these sources. Ten samples were collected respectively from kitchen, laundry and toilet wastewaters were collected and physical, chemical, metallic and non-metallic analysis were carried out on the various samples collected following standard procedures. @JASEM

The problems associated with sewage disposal have become a major problem of the urban world due to increase in human population and urbanization**.** The commonality of sewage related problems throughout urban areas of the world is significant since these areas are inhabited by over 60% of the human population. Consequently, domestic waste-water discharges are considered one of the most significant threats of the coastal environments worldwide (GPA 2001).

Urban areas are facing a variety of pressure affecting both the ecosystem and human health through sewage waste-water discharge and disposal practices that may lead to introduction of high nutrient loads, hazardous chemicals and pathogens causing diseases. The adverse public health, environmental, socio-economic, food quality and security, and aesthetic impacts from sewage contamination in urban areas are well documented (Luker, M. and Brown, C. 1999, Tyrrel, 1999, Danulat *et al* 2002, WHO, 2003).

The disposal of domestic wastewater to land has been carried out in countries for many centuries (Wolman, 2002). The disposal of these wastes became more popular when the pollution of many rivers reached unacceptable levels, as this was the only method of treatment (Metcalf & Eddy, 2002). However with the advent of a range of wastewater treatment options, the approach of controlling water pollution has largely ceased. Disposal of wastewater on land in order to increase crop productivity was also exploited prior to the manufacture of commercial fertilizers and thus, nutrients recycling are not a new practice.

Current practice within Nigeria involves the discharge of effluents to surface water after some preliminary treatment. However, more stringent water quality legislation to protect human health and the environment, and the need to preserve existing water supplies, has led to a re-evaluation of this approach. In fact, emphasis has been placed on reclaiming wastewater in various ways: industrial and non-potable reuse as well as agricultural irrigation have been indicated as the most common types of reuse (De Boer and Linstedt, 2004; Shannon *et al.*, 2003).

Wastewater reuse is advantageous for many reasons such as scarcity of water in arid and semi-arid regions; the high energy cost of advanced wastewater treatment, and the pollution of surface waters as a result of direct discharge of wastewater effluents (Hamilton *et al.*, 2005). Compared to other types of reuse, agricultural use of wastewater effluents presents the additional benefit of nutrient recycling in crop irrigation. Furthermore, effluent irrigation usually demands less stringent water quality standards, and hence simpler and less expensive pretreatment is required. The benefits and potential problems of land application of wastewater have been reviewed by Bouwer and Chaney, (2001) and the dual benefit of using wastewater for irrigation is well recognized. However, wastewater contains more impurities than the original source water and these may be potentially harmful, depending upon the wastewater characteristics and management practices. For instance serious environmental problems such as nitrate leaching, build up of toxic elements in soils and plants, and human health hazards from pathogenic microorganisms may develop. It is thus necessary that the negative impacts should be minimized whilst obtaining the aforementioned benefits.

While standards are required to evaluate the suitability of a given effluent for irrigation, wastewater reuse practices should also adapt the properties of the effluent and the characteristics of the site so as to produce a favourable environment for crop growth. The movement of solutes in the soil depends to a large extent on the movement of water and on the reaction occurring in the soil during effluent irrigation, thus, it is of paramount importance to match reaction rates with the hydraulic loading to ensure successful results. Domestic wastewater constituents that may constrain the hydraulic loading in the short term are usually nitrogen, phosphorus and organic matter (measured as BOD). However, since P and BOD can be assimilated or retained in the root zone, nitrogen remains the limiting parameter (Bayes *et al.*, 2003). Consequently, the selection of an adequate irrigation rate in relation to the nitrogen content of the effluent is a major decision affecting crop production and the impact of wastewater reuse on the environment. Yet, there is an increasing need for efficient management of crops and soils under different effluent application rates. Nutrient uptake by plants is an important factor influencing the choice of such applications. Thus, an improved knowledge of the patterns of nitrogen uptake and utilization is essential to optimize wastewater reuse. Further, management practices based on an understanding of the transformations in wastewater irrigation systems can help increase crop yields and minimize pollution by maximizing the efficiency of nitrogen use.

The disposal of effluent from conventional septic tanks, aerated wastewater treatment systems (AWTS) and sewage treatment works (STW) has the potential to cause serious problems in our environment and more particularly to the soils to which ultimate disposal occurs. The concentration and composition of household chemicals in domestic wastewater are poorly controlled and the usage, by type and quantity is decided upon through arbitrary non-scientific decisions. Sodium, a common constituent in domestic wastewater, remains in ionic form and is not removed by precipitation and filtration processes available in on-site or STW treatment. The effect of sodium on the dispersive properties of soil is well documented (Patterson, 2003).

As urban and industrial development increases, the quantity of waste generated also increases. Wastewater contains a large number of potentially harmful compounds capable of causing the pollution of a watercourse when they are discharged directly into it. Serious damage might result to the death of many forms of life, which inhabit this water. In addition to the watercourse utilized by man, either as a source of potable water or for washing or bathing would present potentials risk for the transmission of large number of water-related disease. To ensure that such problems are avoided or minimized, attention should be paid to the management of our aquatic resources and also of the pollutants, which enter them (Walton 2002).

Domestic wastewater, poses a major environmental problem that requires money and energy to be spent for appropriate treatment and disposal. This is due to the obnoxious manner of the decaying organic matter and the pathogenic organism they habour. However, since domestic wastewater contains beneficial constitutes, their reclamation would not only conserve potable water supplies, but also helps to protect the quality of the environment (Tebbutt, 2004).

The use of domestic wastewater for irrigation is advantageous for many reasons such as water conservation, ease of disposal, nutrient utilization and avoidance of surface water pollution. On the other hand, it must be bored in mind that although the soil is an excellent adsorbent for most soluble pollutants, domestic wastewater must be treated before they can be used for crop irrigation to prevent risk to both public and the environment.

The aim of this study is to determine the properties (Physical, Chemical, BOD, Metallic and Non-Metallic) of domestic wastewater in urban areas in Niger State, Nigeria and to determine the effect of these constituent compounds or elements on the soil and its properties.

MATERIALS AND METHOD

Niger State with Minna as the State capital is one of the major States growing in the north central area of Nigeria which is known for its agricultural activities.

In studying the Quality of Domestic Wastewater and its reuse for agriculture activities in Niger State, ten samples were collected respectively from kitchen, laundry and that of the toilet wastewaters were collected using standard procedures as described by Zamxaka *et al.*, (2004). The samples were labeled T, L and K for toilet, laundry and kitchen wastewaters respectively. Physical, chemical, metallic and non-metallic analysis were carried out on the various samples collected following standard procedures as described by FAO (2004). The parameters examined includes pH, Conductivity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Hardness, Alkalinity, Sodium, Potasium, Magnesium, Manganese, Copper, Zinc, Iron and Lead. Electrical conductivity was measured using a conductivity meter. The chloride, total hardness and total alkalinity were estimated by the standard methods of water and waste water (Gupta *et al.*, 2009).

RESULTS AND DISCUSSION

The results of the analysis carried out are presented in Tables 1, 2 and 3 respectively for the various type of wastewater samples considered for this study.

Table 1: Result for the ten samples of Toilet wastewater (T) TH =Total Hardness; Alk = Alkalinity (mg/L)

S/No	Parameters	Samples T										
		A	B	C	D	E	F	G	H	I	J	Average
1	pH	6.3	5.7	6.4	6.5	6.7	6.67	6.73	5.23	9.43	9.79	6.92
2	Con (dS/cm)	7.9	6.6	6.5	5.3	7.5	8.6	7.845	7.654	8.756	7.946	7.46
3	BOD (mg/ *l*)	126	134	143	125	125	126	124	119	122	123	126.7
4	COD (mg/ *l*)	192.5	191.8	191.9	191.8	191.9	191.7	191.68	191.52	190.98	192.34	191.8
5	TH (mg/L)	76	78	79	76	76.5	77	76.8	74	75	78	76.63
6	Alk (mg/ *l*)	215	216	218	218	220	214	213	216	215	212	215.7
7	Na (mg/ *l*)	143.9	138.	141.9	140.6	142.3	143.7	143.89	142.99	143.98	143.82	142.55
8	K (mg/ *l*)	48.3	44.22	41.6	50.01	49.7	48.3	48.29	48.44	47.49	48.98	47.5
9	Mg (mg/*l*)	16.3	11.2	13.2	17.5	14.3	15.6	14.35	15.63	13.45	12.98	14.4
10	Mn (mg/ *l*)	0.05	0.1	0.2	0.3	0.3	0.08	0.10	0.20	0.18	0.19	0.17
11	Cu (mg/ *l*)	0.1	0.4	0.6	0.8	1.1	1.3	0.56	0.87	0.97	1.01	0.788
12	Fe (mg/ *l*)	0.3	0.3	0.4	0.4	0.4	0.4	0.35	0.42	0.37	0.33	0.372
13	Pb (mg/ *l*)	0.4	0.3	0.5	0.4	0.4	0.4	0.28	0.34	0.26	0.49	0.38
14	Zn(mg/ *l*)	4.0	4.1	4.7	3.9	4.0	4.6	4.5	4.8	4.2	3.4	4.22

Table 2: Results for the ten samples of Kitchen wastewater (K)

S/No	Parameters	Samples K										
		A	B	C	D	E	F	G	H	I	J	Average
1	pH	5.69	5.65	5.62	5.67	5.76	5.45	5.68	5.68	5.69	5.71	5.66
2	Con (dS/cm)	2.560	2.479	2.539	2.547	2.562	2.567	2.576	2.564	2.559	2.557	2.551
3	BOD (mg/ *l*)	48	48.70	48.12	48.13	47.96	48.01	48.05	48.98	48.02	49.51	48.348
4	COD (mg/ *l*)	124.12	123.87	124.02	124.11	124.11	124.14	124.08	124.13	124.07	124.09	124.074
5	TH (mg/L)	198	200	199	198	190	197	196	196	197	198	196.9
6	Alk (mg/ *l*)	480	481	479	487	481	478	479	482	483	481	481.1
7	Na (mg/ *l*)	176.09	178.93	178.99	176.93	176.53	176.42	176.36	176.24	176.11	176.08	176.868
8	K (mg/ *l*)	62.60	62.57	62.45	62.76	61.99	63.07	63.17	62.97	62.67	62.69	62.694
9	Mg (mg/*l*)	9.07	8.97	8.99	8.89	9.02	9.04	9.08	9.06	9.09	9.05	9.026
10	Mn (mg/ *l*)	0.28	0.27	0.27	0.30	0.29	0.31	0.29	0.29	0.27	0.28	0.285
11	Cu (mg/ *l*)	0.13	0.11	0.10	0.09	0.08	0.12	0.11	0.10	0.14	0.13	0.111
12	Fe (mg/ *l*)	0.50	0.51	0.58	0.59	0.58	0.51	0.53	0.52	0.50	0.48	0.53
13	Pb (mg/ *l*)	0.3	0.2	0.3	0.28	0.31	0.34	0.29	0.32	0.30	0.31	0.295
14	Zn(mg/ *l*)	4.5	4.8	4.6	4.2	4.3	4.9	4.6	4.7	4.4	4.3	4.53

Table 3: Results for ten samples of Laundry wastewater (L)

S/No	Parameters	Samples L										
		A	B	C	D	E	F	G	H	I	J	Average
1	pH	4.22	4.67	5.78	4.76	4.97	4.98	4.33	4.35	4.21	4.20	4.647
2	Con (dS/cm)	4.220	4.230	4.234	4.267	4.235	4.234	4.342	4.135	4.236	4.354	4.2487
3	BOD (mg/ *l*)	66.30	65.45	67.23	67.46	65.54	65.67	67.01	68.00	67.78	67.47	66.791
4	COD (mg/ *l*)	168.20	167.20	167.23	166.75	167.64	168.36	167.45	167.16	165.67	168.21	167.387
5	TH (mg/L)	336	342	340	338	337	329	327	328	342	332	335.1
6	Alk (mg/ *l*)	426	436	435	426	476	436	425	453	436	427	437.6
7	Na (mg/ *l*)	198.32	198.22	197.47	198.22	198.45	198.56	197.07	198.06	198.27	198.46	198.11
8	K (mg/ *l*)	84.22	84.32	84.47	84.46	84.41	84.49	84.45	84.98	83.99	83.96	84.375
9	Mg (mg/*l*)	37.36	36.79	36.75	36.98	36.96	36.94	36.99	37.25	37.34	37.39	37.075
10	Mn (mg/ *l*)	0.02	0.01	0.02	0.02	0.10	0.07	0.01	0.02	0.03	0.02	0.032
11	Cu (mg/ *l*)	0.30	0.29	0.27	0.31	0.33	0.30	0.33	0.30	0.31	0.31	0.305
12	Fe (mg/ *l*)	2.80	2.82	2.79	2.78	2.77	2.87	2.81	2.84	2.82	2.81	2.811
13	Pb (mg/ *l*)	0.9	0.87	0.88	0.88	0.91	0.93	0.92	0.92	0.91	0.87	0.899
14	Zn(mg/ *l*)	4.4	4.1	4.3	4.6	4.7	4.6	4.8	4.4	4.2	4.2	4.43

Table 4: Nigerian water quality standard

Parameters	Units	Maximum permissible limit
Alkalinity	mg/L	150
Barium	mg/L	0.7
Cadmium (Cd)	mg/L	0.003
Chloride (Cl)	mg/L	250
Chromium (Cr6+)	mg/L	0.05
Conductivity	dS/cm	1
Copper (Cu+2)	mg/L	1
Cyanide (CN-)	mg/L	0.01
Fluoride (F-)	mg/L	1.5
Hardness (as CaCO3)	mg/L	150
Hydrogen Sulphide (H2S)	mg/L	0.05
Iron (Fe+2)	mg/L	0.3
Lead (Pb)	mg/L	0.01
Magnesium (Mg+2)	mg/L	0.2
Manganese (Mn+2)	mg/L	0.2
Mercury (Hg)	mg/L	0.001
Nickel (Ni)	mg/L	0.02
Nitrate (NO3)	mg/L	50
Nitrite (NO2)	mg/L	0.2
pH	-	6.5-8.5
Sodium (Na)	mg/L	200
Sulphate (SO4)	mg/L	100
Total Dissolved Solids	mg/L	500
Zinc (Zn)	mg/L	3
COD	mg/L	150
BOD	mg/L	50

Source: Nigerian Standard for Drinking Water Quality (2007)

A growing awareness of the potential of wastewater reuse for improvement and development of crop production arose in the last decades, with the widespread droughts, while irrigation may be the most obvious response to drought in Niger State and Nigeria at large. The sets of results of wastewater for the various samples are presented in Tables 1, 2, and 3 with the Nigerian Standard for Drinking water Quality presented in Table 4. Averages for each of the parameters are calculated for at the last column of each of the tables.

pH Quality: The acidity or basicity of irrigation water is expressed as pH (< 7.0 acidic; > 7.0 basic). In Nigeria the same standard for drinking water quality is used as irrigation water quality standard. The normal pH range for irrigation water is from 6.0 to 8.5. From results obtained, the average pH for sample T was calculated to be 6.918, which is within the Nigerian water Drinking Quality Standard, thus showing that there was less contamination of sample T. Samples K and Lhad an average value of 5.66 and 4.647 which were both below the recommended standard thus showing that the wastewater produced here is slightly acidic which if applied directly to any irrigated field may affect crops planted in such area.

pH is an indicator of the acidity or basicity of a water, but is seldom a problem by itself. The main use of pH in a water analysis is for detecting abnormal water. An abnormal value is a warning that the water needs further evaluation. Irrigation water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion.
Low salinity water sometimes has a pH outside the normal range since it has a very low buffering capacity. This should not cause undue alarm other than to alert the user to a possible imbalance of ions and the need to establish the reason for the adverse pH through full laboratory analysis. Such water normally causes few problems for soils or crops but is very corrosive and may rapidly corrode pipelines, sprinklers and control equipment.

Any change in the soil pH caused by the water will take place slowly since the soil is strongly buffered and resists change. An adverse pH may need to be corrected, if possible, by the introduction of an amendment into the water, but this will only be practical in a few instances. It may be easier to correct the soil pH problem that may develop rather than try to treat the water. Lime is commonly applied to the soil to correct a low pH and sulphur or other acid material may be used to correct a high pH. Gypsum has little or no effect in controlling an acid soil problem apart from supplying a nutritional source of calcium, but it is effective in reducing a high soil pH (pH greater than 8.5) caused by high exchangeable sodium.

The greatest direct hazard of an abnormal pH in water is the impact on irrigation equipment. Equipment will need to be chosen carefully for unusual water.

Conductivity (Electrical Conductivity): Water with electrical conductivity (EC_w) of only 1.150 ds/m contains approximately 2,000 pounds of salt for every acre foot of water. The most influential water quality guideline on crop productivity is the water salinity hazard as measured by electrical conductivity (EC_w). The primary effect of high EC_w water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the EC, the less water is available to plants, even though the soil may appear wet. Because plants can only transpire "pure" water, usable plant water in the soil solution decreases dramatically as EC increases. The average EC for samples T, K and L are 7.4651, 2.551 and 4.2487 respectively. When compared with the recommended standard of 4.883.33ds/m > 3.000, it was observed that only sample L fits in. Hence, the wastewater for samples T and K has to undergo at least a primary water treatment to reduce the EC value to a reasonable amount.

Biological Oxygen Demand (BOD) and Carbon Oxygen Demand (COD): From the result obtained from the analysis the average BOD and COD of the three (3) samples T, K and L was found to be 126.7 mg/L, 48.348 mg/L and 66.791 mg/L while that of the COD was 191.828 mg/L, 124.074 mg/L and 167.387 mg/L respectively. When these results were compared with the approved standard for drinking water quality in Nigeria, it was observed that only sample K was slightly below standard for BOD, thus making it valuable for irrigation purpose. Samples T and L were found to be higher which does not its usage for irrigation purpose. Only sample K when compared with the standard for COD was within the range for which it had 124.074 mg/L. Thus it making it suitable for use for irrigation purpose while the other two samples will have to be treated before they can be used for irrigation activities.

Alkalinity: Alkalinity in wastewater results from the presence of hydroxides, carbonate and bicarbonates of reactive metals like calcium and magnesium. From the results shown in Tables 1, 2 and 3, it was discovered that the average alkalinity for samples T, K and L are 215.7 mg/L, 481.1 mg/L and 437.6 mg/L respectively and when these values were compared with the standard, only sample T was observed to be closest though not within the immediate maximum permissible limit was sample T. This may be as a result of various human waste which must have reacted with each other thus reducing the alkalinity level and it also be said that it will be easier to treat wastewater from sample T for agricultural purpose than the other samples.

Sodium: The results showed that the average concentration of Sodium in samples T, K and L were 142.554 mg/L, 176.868 mg/L and 198.11 mg/L respectively. The results obtained were observed to be within the range of the maximum permissible limit of 200 mg/L. Thus implying that wastewater from the three samples can be applied directly to any agricultural field. Thus implying that with little or no treatment the wastewater samples was found to be good for irrigation purposes. Though, good soil analysis should be conducted to determine the level of salt in the area these wastewater samples are to be applied.

Magnesium: The concentration of magnesium was found to be 14.473mg/L, 9.026mg/L and 37.075 mg/L for samples T, K and L respectively which is below the maximum limit (50mg/l) of water for irrigation and agricultural purposes. Calcium and magnesium, if present in the soil in large enough quantities, will counter the effects of the sodium and help maintain good soil properties. But Crops grown on soils having an imbalance of calcium and magnesium may also exhibit toxic symptoms an imbalance of magnesium and potassium may be toxic, but the effects of both can be reduced by high calcium levels.

Copper: Copper, can be toxic or may otherwise adversely affect aquatic life when present above maximum permissible concentrations, although their presence in low amounts is essential to support and maintain functions in aquatic ecosystems. From the Tables 1, 2 and 3, the average concentration of copper samples T, K and L are 0.788 mg/L, 0.111 mg/L and 0.305mg/L respectively. It was observed that only sample K was within the maximum permissible limit of 0.2mg/L.

Conclusion: Direct use of domestic wastewater (untreated wastewater) may not be healthy for agricultural purposes expect it undergoes certain wastewater treatment process. Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, thus affecting the permeability/uptake of water from the soil to the plants. Contaminants in irrigation water when it accumulates overtime in an agricultural soils renders such soils unfit because of the accumulation of salts and other heavy metals present in the soil; thus reducing arable crop farming in agricultural activities. For wastewater in Minna metropolis in Nigeria to be useful for arable crop farming there are several options for which the farmer can use to improve its quality one of which, as described by Patterson (2003) is that the farmers may be the blending of treated sewage with conventional sources of water, canal water or ground water, if multiple sources are available. It is possible that a farmer may have saline ground water and, if he has non-saline treated wastewater, he could blend the two sources to obtain a blended water of acceptable salinity level. Further, by blending, the microbial quality of the resulting mixture could be superior to that of the unblended wastewater.

Another is the creation of on-farm drainage systems to channel away from the farmland excess/ wastewater hence reducing the salinity level and lowering the water table to a desirable level, at which it does not contribute to the transport of salts to the root zone and the soil surface by capillarity.

Another strategy is to use untreated wastewater alternately with treated wastewater, canal water or groundwater, instead of blending. From the point of view of salinity control, alternate applications of the two sources will be superior to blending. However, an alternating application strategy will require dual conveyance systems and availability of the effluent dictated by the alternate schedule of application.

Recommendation: In this study, the quality evaluation of domestic wastewater for agricultural purposes, encountered a lot of problems, one of which is the unavailability of proper standard for the quality of water for irrigation and agricultural purposes in Nigeria which has in did lead to the use of that of the drinking water quality standard. Hence, it is therefore recommended

- A standard irrigation water quality standard is made available for us in Nigeria to serve as a guide for the farmers in the country.
- Other sources of wastewater are analyzed to enrich the standard that will be provided for use by the various categories of arable farmers.
- Mini collection and treatments points should be provided in such a way that it will be close to the farmers. This is to avoid the direct use of such wastewater for agricultural activities.

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