Geo-Environmental Impact Assessment of Effluent Water Disposal on Underground Water in Parts of Samaru, Zaria Kaduna State, Nigeria.

Afolalu Felix Olugbenga

Department of Science Lab Technology, Nuhu Bamalli Polytechnic, Zaria, Nigeria.

E-mail: afocalculus@yahoo.com

ABSTRACT

The liquid waste in Samaru – Zaria was monitored to determine the concentrations of contaminants in groundwater within and around the area to meet regulatory requirements. The degree of the environmental contamination depends on the characteristics of the soil and groundwater type and the concentration of contaminants present. From the Casagrande plasticity chart, the soil forms a part of leached ferruginous soil type which is mostly formed from the crystalline metamorphic rocks of granite gneiss. The results revealed that of the forty two (42) samples, the mean removal efficiencies considered are 50.1%, 43.4%, 76.9%, 49.2%, 84.3%, and 36%, of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solid (TDS), suspend solid (SS), nitrate (NO-3), and phosphate ($PO4^{2-}$), respectively, are higher than the Word Health Organization (WHO) maximum admissible values. This suggests contamination of groundwater by natural and anthropogenic sources. Finally, the environmental evaluation shows that the concentrations of contaminants in the soils of the study areas where inversely proportional to depth and there is an increase in contaminants that were present in groundwater when compared to leachate.

(Keywords: groundwater contamination, BOD, COD, TDS, SS, nitrate, phosphate)

INTRODUCTION

"Every organism, whether large or small, plant or animal, bring about change in its environment in the course of its life" (Daimant, 1974). This statement summarizes the unavoidable impact of inhabitants on the environment. Man in his day-to-day activities generates waste as a by product of his handiwork or metabolism. Lack of proper disposal of these wastes have led to environmental impact of epidemic proportions in both ancient times and in recent times. Unchecked disposal of waste has led to drastic changes in the environment such as acid rain, global warming, and even the extinction of certain animal and plant species.

An assessment of the present situation in wastewater disposal from latrines connected to septic tanks (water system toilet) or pit latrines is examined here. The wastewater from bathrooms and kitchens is directly connected to the drains and is ultimately discharge into water bodies. This places high demands on the water body for dissolved oxygen (DO). Should the DO content of the water body fall below certain levels, the wastewater could trigger a fish kill and affect the aquatic inhabitants. Most septic tanks constructed behind most houses lack proper maintenance and also the time the wastewater spends in the tanks are reduced. This turns the tanks and drainage into a breeding ground for disease carrying insects, rodents, etc.

Septic tanks requires large area of permeable subsoil through which it can distribute effluents, but in highly populated areas the required open spaces for this purposes are too limited for its widespread use. In most cases when wells are built in areas due to scarcity of pipe-borne water, relying on septic tanks could hasten the spread of disease, especially if the subsoil structure is too impermeable for the leaching of tank effluent and wastewater is laden with pathogens. Another problem associated with septic tanks is that if located close to buildings, they can weaken the structural stability of the foundation. Nitrate contamination has also long been considered a major threat to health in highly agricultural area where groundwater is used as drinking water source. (Alpha, 1985).

According to Danjuma (1996), the leaching effect of rain becomes more pronounced where the ground is permeable and the well are shallow and observed that after long periods of dryness, high quantities of nitrogen were accumulated in the superficial layer of the ground. The input of nitrates via, the use of artificial fertilizers and organic decay in our rural areas, particularly where portable water is not always available, presents a potential danger signal to human health in view of the emphasis of nitrates after reduction to nitrite could cause methaemoglobinaemia in infants and could also be responsible for gastric cancer when converted to nitrous compound (Ali, 2001).

Furthermore, the few industries located around the out sketch of Zaria produce waste-water which contains high organic percentage. This wastewater is toxic to aquatic life and since the major rivers do not flow either across or along the industrial layouts they are disposed of after treatment on the ground surface (farm land). If not properly treated, they hamper the growth of plants.

THE STUDY AREA AND LOCATION

The study area, Samaru, is in the tropical wet and dry climatic zone, characterized by strong seasonality in rainfall and temperature distribution (Bound, 1994). Seasonality in climatic condition is caused by the oscillation over the study area two air masses, the Maritime Tropical air mass (MTS) and the Continental Tropical air mass (CTS), with contrasting rainfall and temperature characteristics. When the MTS is prevailing, the study area experiences a rainy season while the CTS ushers in the dry season with its cold, dry and dusty air which occasionally limits visibility and reduces solar radiation.

The rainy season has a short duration and it is followed by 5—7 months of dry season. The beginning of the rainy season is not predictable, although the long term average appears to begin in first week in May.

The Zaria region, by virtue of its position, has Koppen's climate, (AW) which is the tropical continental. Daily maximum temperatures show a major peak in April and a minor one in October. The mean minimum temperature rises from its lowest value of about 11 degrees Celsius, in December and January to a high temperature of about 40 degree Celsius in July/August. Thus, the region is said to have distinct wet and dry seasons. The wet season occurring during the high sun period. The dry season is practically rainless and normally starts from around October and ends in April. The seasonal characteristics affects the vegetation cover (Gordy, 1991).

SOIL, GEOLOGY AND VEGETATION

The soil of Zaria, in which Ahmadu Bello University resides, forms a part of leached ferruginous tropical soil type which is mostly formed from the crystalline metamorphic rocks of granite gneiss. Most of the soil is 30-40 percent of clay soil, which has the ability to retain moisture.

The soil is said to be lateritic in nature, reddish in color, ensuring a reasonably free drainage. Their clay is predominately of kaolin with iron and aluminum oxides. Laterites tend to range from neutral at the surface becoming progressively more acidic down through the horizon. The degree of acidity will depend on the level of rainfall, which when heavy, causes excessive leaching. The soil has been classified as ferruginous tropical soil developed on weathered regolith rich in fine-grained quartz and oligoclase. It is overlain by the deposit of wind-blown silts from the Sahara desert during many decades of the propagation of CTS into the study (Wright, and McCurry, 1970).

The soil has a sandy loam texture. The soil also exhibits a marked horizon differentiation with deposits of concretion mottle and nottles underlying the A- horizon. Iron oxide are deposited in the clay rich B-Horizon in the form of mottles, concretion or as ferruginous hard pans called duricrust (Onuoha, 1998).

The soil is relatively low in organic matter content (1-2%) and cation exchange capacity (C.E.C). The soil profile is usually less than 150cm deep, below which occur partially weathered rocks of the parent materials. High rainfall and high temperature means that deposition is continuously occurring in the upper layer, this result in low humus content on the soil and the nutrients are leached out.

Like other parts of Zaria, Samaru is underlain by differentiated pre-Cambrian basement complex formation comprising of both igneous and metamorphic rocks. Basement geology which consists of metamorphic rocks are a product of the last two orogenic cycles (Oladoja, 1999). The last of these possibly extended from late Precambrian to lower Paleozoic (Grant, 1996).

Furthermore, published geological information indicates that undifferentiated basement complex of migmatites, granites, gneisses and metasediments is overlain by laterites. The pressure of the steep isoclinic folding of the Zaria metasediments resulted from orogenic movement in pre-Cambrian time, with the formation of north east and north/north east striking faults, following the period of the folding about the time of intrusion of the 'older granite'. This major fault reflects major component of movement, being transverse displacement between 2 to 10km. the fault occur as shatter zone of varying width, up to 7km. atypical feature which marks the major faults is quartz veining and ridges of silicified breccia. The Kubani river is built up with such quartz ridges. Generally, the northern part of Samaru is flat to undulating and increases in elevation to the west. The southern part of the study area rises gradually from the Kubani River to form gently rolling features, with the terrain increasing to the west.

OBJECTIVES

a. Examine the use of septic tank in the study area as against draining Sewage into open drainage.

b. Examine the geo- environmental impact of sewage in open drainage on the ground water in Samaru area.

MATERIALS AND METHODS

In this study, effluent quality and performance of three septic tanks were evaluated under three different arrangements of domestic wastewater connection to the tank, viz; septic tank receiving:

(a) toilet wastewater only (arrangement 1),
(b) toilet and kitchen wastewater (Arrangement 2), and
(c) toilet, kitchen and bathroom (Arrangement 3).

Three test sites located in Samaru were selected. These sites represent typical residential areas with individual septic tanks (one for each building) and soakage pits. These systems overflow and require frequent cleaning. The selected test sites are.(a) Dan raka Area (b) Hayin Dogo and (c) New Extension.

Information on wastewater generation rates at the three sites is provided in Table 1. All the three selected septic tanks are single compartments where inlet and outlet pipes are "T" shaped and of 100mm diameter. The tanks are made of sandcrete walls with concrete floor and reinforced concrete top. The sides of the soakage wells are sandcrete walled up to 240mm depth. The top of the pit is covered with concrete slab without any opening. At all the test sites, only toilet wastewater lines were connected to the septic tank (i.e., Arrangement 1). Before starting the experiment all the septic tanks were cleaned and test (under Arrangement 1) started three weeks after cleaning.

For tests under Arrangement 2, Kitchen wastewater lines were connected to the septic tanks using PVC pipes and were allowed to remain in this condition for three weeks for attainment of equilibrium conditions before testing began.

The same procedure was followed for testing under Arrangement 3. It is worth nothing that in these study existing septic tank systems were utilized and as a result inflow and outflow rates and hence detention time of wastewater in the septic tank could not be kept the same for different combinations of wastewater. For instance, flow rates were significantly higher under Arrangement 2 and 3 compared to Arrangement 1 and as a result, detention time under Arrangement 2 and 3 were much shorter. This obviously had marked influence on the efficiency of the septic tanks.

Effluent samples were collected at the inlet point of the soakage pits. Influent wastewater quality was tested by collecting samples at the inlet point of the septic tanks. Influent and effluent samples were tested for a range of parameters including suspended solids (SS), total organic carbon (TOC), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO3), phosphate (PO4), and fecal coliforms (FC). Nitrate and phosphate concentrations were determined using a spectrophotometer (Hach DR EL/4), TOC was determined using a Yanco TOC Analyzer (model TOC-81). Other parameters were determined following standard procedures (APHA, 1985).

Soil absorption capacities of effluents generated under the three different arrangements were measured by standard percolation test at test sites 1 and 3. It should be mentioned that the soil absorption capacities were measured during the dry season and results are expected to be different if the tests are conducted during the wet period of the year.

According to the Mara (1976) report sewage is defined as the wastewater of a community, which may be purely domestic in origin or may contain some industrial or agricultural wastewater as well. Domestic sewage is composed of human body waste (feces and urine) and silage which is the wastewater resulting from personal washing, laundry, food preparation and the cleaning of kitchen utensils. Fresh sewage (which is the type of sewage found in Samaru) is a gray turbid liquid which has an earthly but in-offensive odor. Sewage soon loses it's content of dissolved oxygen in hot climates and so becomes septic, which has the most offensive odor, usually of hydrogen sulphide. In the teaching hospital, the composition of sewage is usually of substance from the theater and laboratories like infusion and blood bags, cotton wools, etc.

ANALYSIS OF SAMPLES

All samples were collected in 4 liters jerry cans over a period of time. These samples were analyzed in the laboratory according to the standard methods (16^{th} Edition, APHA, 1985).

BIOCHEMICAL OXYGEN DEMAND (BOD)

Biochemical oxygen demand (BOD) of the sample was determined using the unmodified Wrinkler's method as specified in the standard method ($l6^{1h}$ edition, JIPHA, 1985).

$BOD_5 = (D_o - D_s) X P = (MG/L)$

Where,
D_o is the day zero dissolved oxygen
D_5 is the day five-dissolved oxygen
P is the fraction of dilution and is given as

$$P = \frac{\text{final volume used}}{\text{Initial volume taken}}$$

CHEMICAL OXYGEN DEMAND (COD)

Chemical oxygen demand (COD) of the samples was determined using the reflux method as specified in the standard method (16^{th} edition, AP AH, 1985).

$$COD\ (MG/L) = \frac{(a-b) \times N \times 8000}{\text{Ml of sample used}}$$

Where,
A = ml of fe$(NH)_2$ - $S0_4)_2$ used for blank ,
N = Normality of Fe$(NH)_2$ - $(SO_4)_2$ used
B = ml of Fe (NHh - $(S0_4)_2$ used for sample

TOTAL DISSOLVED SOLID (TDS)

Sample analysis for, total and dissolved solid were evaporated and filtered respectively as specified in the standard method (16^{th} edition, APHA 1985) .

Total solid in mg/l = $1000 (W_2 – W_1)$

Where,
W_2 = weight of evaporation dish
W_1 = weight evaporating dish and residue
Dissolved solid (mg/1 =1000 $(w_2 – w_1^1)$

SUSPENDED SOLIDS

Samples to be analysis for suspended solid were evaporated and, filtered respectively as specified in the standard method (16^{lh} edition, APHA 1985)

Suspended solid (mg/l) $(W_2 – W_1^1)$

Where
W_2 = weight of evaporating dish
W_1= weight of evaporating dish and residue

pH

The pH of the sample of effluent was carried out as specified in the standard method ($l6^{lh}$ edition, APHA 1985).

NITROGEN - NITRATE ($N-N0_3$-)

Nitrogen - nitrate in the samples were determined using method as specified in the (standard method (16^{th} edition, APHA 1985).

Nitrogen - Nitrate ($N-N0_3$-)(mg/l)
$MgNO_3$ x 1000
Ml of sample used

PHOSPHATES ($P0_4^{2-}$)

Specified in the standard method (16th edition APHA 1985).

$$P0_4^{2}\text{-}= \frac{(Mg/1)\ mg\ PO \times 1000}{Ml\ of\ sample\ used}$$

ALKALINITY

The alkalinities of the samples were determined using the method as specified in the standard method (16th edition, APHA; 1985).

$$\text{Total alkalinity} = \frac{B \times N \times 50{,}000}{M1\ of\ sample\ used}$$

Where,

B = ml of titration for sample to reach methyl orange end point
N = normality of acid

RESULTS AND ANALYSIS

The results obtained from the analysis of the raw wastewater from the septic tanks in the three sites and wastewater which are allowed to flow into open drainage are presented under the following sections;

1. Performance test of three septic tanks from three sites (Dan raka, Hayin dogo, New Extension).
2. Results from wastewater in open drainage.

Table 1: Performance of Septic Tank Receiving Toilet Wastewater (Arrangement 1).

Site	Sample	N	Detention Time	Raw Sewage	Effluent	Removal Efficiency, %
	BODs (mgr^1)	3		633.2 + 31.7(665-603)	290.2+ 6.4(296.4-283.7)	54.2
	COD (mgr^1)	3		750.9 + 15.9(765-734)	321.6 + 23.3(347-301)	57.2
	TDS (mgr^1)	3		330.3 + 1.5(332-329)	165.3 + 2.5(168-163)	50.0
1	SS (mgr^1)	3	24hrs	270.5 + 1.8(272-269)	169.6+ 5.0(175-165)	37.3
	$P0_4$ (mgr^l)	3		40.3+ 2.5(43-38)	20.3 + 1.5(22-19)	49.6
	$N0_4$(mgr^1)	3		43.4+ 6.0(48-36)	18.8+ 0.2(19-18.5)	56.7
	FC(l0G /l00G$_m$)	3		15.0 + 2.0(17-13)	5.2 + 0.5(5.7-4.8)	65.3
2	BODs (mgj"l)	3		635. + 6.0(642-630)	307.7+ 2.7(310-304)	51.6
	COD (mgj"l)	3		849.4 + 5.7(854.7)	398.7 + 2.7(400-395)	53.1
	TOC (mgr^1)	3		285.3+ 1.6(287-283)	155.1 + 3.9(159-152)	45.6
	SS (mgr^l)	3	48Hrs	272.6+ 2.5(275-270)	190.5+ 3.7(194-186)	30.1
	$P0_4$ (mgr^1)	3		61.1 + 3.4(64.9-58.5)	25.2 + 1.3(26.0-23.7)	58.8
	$N0_4$ (mgr^l)	3		32.3 + 3.1(35-29)	17.7 + 1.3(19-16.5)	45.2
	FC(1 0^6/1 006$_m$l)	3		20.3 + 3.5(24-17)	10.7 + 3.3(14-7.4)	47.3
3	BODs (mgj"l)	3		596.4 + 9.1(602-586)	254.0 5.3(260-250)	57.4
	COD (mgr^1)	3		790.4 + 9.7(800-780)	337.3 21.3(361-320)	57.3
	TOC (mgr^l)	3		382.0 + 2.0(384-380)	263.0 6.2(270-258)	31.2
	SS (mgj"l)	3	72hrs	124.3 + 3.9(128-120)	73.9 3.4(76.9-70.3)	40.6
	$P0_4$ (mgr^l)	3		64.9+ 4.9(69.8-60)	22.1 1.9(23.5-19.9)	66.0
	$N0_4$ (mgr^1)	3		37.1+ 2.4(39.6-34.8)	20.3 2.5(23- 18)	45.3
	FC(10^6/1006$_m$l)	3		6.7 + 1.1(7.8-5.7)	3.6 0.7(4.3-2.9)	46.3

Source: Field survey 2008

Table 2: Performance of Septic Tank Receiving Toilet, Kitchen Wastewater (Arrangement 2).

Site	Sample	N	Detention Time	Raw Sewage	Effluent	Removal Efficiency, %
	BODs (mg^{l})	3		231.3 + 6.1(238-226)	110.0 + 10.0(120-100)	52.4
	COD (mgl)	3		370.6 + 6.0(377-365)	169.3 +4.0(173-165)	54.3
	TOC (mg^{l})	3		181.0 + 5.6(187-176)	91.0+ 3.0(94-88)	49.7
1	SS (mg^{l})	3	24hrs	90.0 + 3.6(94-87)	65.3 + 4.0(69-61)	27.4
	P0$_4$ (mg^{l})	3		10.7 + 4.0(15-7)	5.0 + 2.0(7-3)	53.3
	N0$_4$ (mg^{l})	3		51.0 +4.6(56-47)	40.0+ 3.0(43-37)	21.6
	FC(1 0('/1	3		251 +5.6(257-246)	150 +3.0(153-147)	40.2
	BODs (mg^{l})	3		262.7 + 5.9(267-256)	116.9+ 2.3(119.3-114.7)	55.5
	COD (mg^{l})	3		302.3 + 6.8(310-297)	120.7 + 2.8(123.8-188.4)	60.1
	TOC (mg^{l})	3		96. 1+1.9(98.1-94.3)	, 49.1+ 3.3(52.1-45.5)	48.9
2	SS (mg^{l})	3	48hrs	71. 1+2.6(73.7-68.6)	46.0 + 1.0(47-45)	35.3
	P0$_4$ (mg^{J})	3		35.5 +2.2(37.9-33.6)	21.5 + 2.0(23.7-19.9)	39.4
	N0$_4$ (mg^{l})	3		50.6 + 2.3(53.1-48.6)	30.3+ 2.7(33.2-27.8)	40.1
	FCC I	3		15.0 + 0.4(15.4-14.70)	10.3 + 0.6(10.9-9.9)	31.3
	BODs (mg^{l})	3		180.8 + 2.6(183.7-178.7)	60.3 +2.5(62.9-57.9)	66.7
	COD (mg^{l})	3		302.7 + 6.8(310.5-297.7)	108.3 + 7.6(1 15-100)	64.2
	TOC (mg^{l})	3		82.9+ 2.3(85.3-80.7)	32.7 + 2.5(35-30)	60.6
3	SS (mg^{l})	3	72hrs	80.3 + 1.6(82.1-78.9)	40.6 + 2.3(43.2-38.7)	49.4
	P0$_4$ (mg^{1})	3		45.0+ 2.0(47-43)	25.3+ 2.2(27.6-23.3)	43.8
	N0$_4$ (mg^{l})	3		35.9 + 1.5(37.6-34.7)	18 + 1.0(19-17)	49.9
	FC(10^6/1006_m)	3		9.3 + 0.7(10.20-8.7)	5.6+ 0.5(6-5)	39.8

Source: Field survey 2008

Tables 1, 2 and 3 show removal efficiencies of the septic tanks under three different test arrangements. Detention time under each arrangement is also indicated in the tables. Table 1 shows that under the Arrangement 1 (septic tank receiving toilet wastewater only), the composition of raw sewage are similar for septic tanks at sites 1 and 2, while concentrations of tested parameters are significantly lower for septic tank at sites 3. As shown in Table 1, removal efficiencies of different constituents are better at site 3. A comparison of raw sewage characteristics presented in Table 1 and 2 shows that combination of toilet and kitchen wastewater significantly reduces the BOD5 and COD loadings of the raw sewage.

TOC and SS concentrations are also reduced while NO_3 concentration increased. A comparison of removal efficiencies presented in Tables 1 and 2 also shows that reduction in detention time in Arrangement 2, actually improved the removal efficiencies of BOD5, COD, TOC and SS as compared to Arrangement 1. On the other hand PO_4, NO_3 and FC removal efficiencies have diminished, probably due to reduction in detention period.

Table 3 shows that combination of kitchen, toilet and bathroom wastewater reduces the BODS, and COD loading even further due to dilution with bathroom wastewater. The corresponding changes in influent. TOC and SS concentrations are relatively smaller. A comparison of Tables 1, 2 and 3 shows that despite a significant reduction in detention time, BOD5, COD and SS removal efficiencies have actually improved under Arrangement 3 compared to Arrangements 1 and 2.

A comparison of these tables revealed that septic tank effluent quality with Arrangement 2 and 3 is better than that of Arrangement 1 with respect to BOD5, COD, TOC and SS.

Table 3: Performance of Septic Tank Receiving Toilet, Kitchen & Bathroom Wastewater (Arrangement 3)

Site	Sample	N	Detention Time	Raw Sewage	Effluent	Removal Efficiency, %
	BODs (mgr^{1})	3		110.7 + 4.0(115-107)	40.9 + 1.9(43.1-39.7)	63.1
	COD (mgr^{l})	3	24hrs	175.2 + 49(207-48.7)	59.5 + 2.1(61.3-57.3)	66.1
	TOC (mgr^{l})	3		121.5 + 2.0 (123.7)	54.9 + 1.9(56.9-53)	54.8
	SS (mgr^{1})	3		80. + 1.4(81.4-78.6)	36.1 + 2.1(38-33.9)	54.9
1	$P0_4$ (mgr^{1})	3		6.2 +0.4(6.7-5.9)	4 + 1(5-3)	35.
	$N0_4$(mgr^{1})	3		41.0 + 3.6(45-38)	37.7+ 2.5(40-35)	8.1
	FC(10^6/100^6ml)	3		13.2 + 0.6(13.9-12.7)	9.4 +0.6(9.9-8.7)	28.9
	BODs (mgr^{1})	3		111.3 + 6.1(118-106)	45.1 + 1.7(46.3-43.1)	59.5
	COD (mgr^{1})	3		190.3 + 3.1(193.3)	50.7+ 2.2(53.1-48.7)	73.4
	COD (mgr^{1})	3		85.1+ 3.0 (87.9-81.9)	45 + 2.0(47-43)	47.1
2	SS (mgr^{1})	3	48hrs	77.9 + 1.8(79.5-76)	40.6 + 2.3(43.1-38.7)	47.9
	$P0_4$ (mgr^{1})	3		65 + 2.0(67-63)	21.4+ 2.1(23.7-19.8)	67.1
	$N0_4$ (mgr^{l})	3		55.2+ 1.5(56.8-53.9)	10.1 + 0.4(10.5-9.8)	81.7
	FC($10^6$1100^{6}ml)	3		11. 7+ 1.5(13-10)	9.1+ 0.5(9.7-8.7)	22.2
	BODs (mgr^{1})	3		110.3 + 4.5(115-106)	35.3 + 1.5 37-34)	68.0
	COD (mgr^{1})	3		209.7 + 4.5(214-205)	61.1+ 2.9 64.3-58.9)	70.9
	TOC (mgr^{1})	3		102.3 + 2.59(105-100)	60.6+ 2.3 60.6-587)	40.8
3	SS (mgr^{1})	3	72hrs	85.4 + 1.4(86.5-83.8)	34.7 + 2.5(37-32)	59.4
	$P0_4$ (mgr^{1})	3		45.0 + 2.1(47.1-43.0)	30.1+ 0.530.7-29.7)	33.1
	$N0_4$ (mgr^{1})	3		30.3+ 2.5(33-28)	19.3 +1.5(21-18)	36.3
	FC(10^6/100^Gml)	3		8.0 + 2.0(10-6)	5.4 +0.5(5.7-5.0)	32.5

Source: field survey 2008

Table 4: Soil Absorption Capacities of Septic Tank Effluents.

Test site	Effluent type	Absorption rate (L/m^{2}d)	Seepage area required (m^2)
Site 1	T	61	25
	T+K	63	24
	T+K+B	66	23
Site 2	T	78	19
	T+K	79	19
	T+K+B	83	18

T = Toilet, K = Kitchen, B = Bathroom (Source: field survey 2008)

Better quality with respect to FC could probably be achieved under Arrangement 2 and 3. It should be noted that flow rates of wastewater increased significantly under Arrangements 2 and 3 which would require a much larger tank volume as to maintain a constant detention time.

Table 4 shows the results of percolation tests conducted at the test sites 1 and 2 with effluents from all three test arrangements. It also shows that percolation rates slightly increases with toilet and kitchen wastewater for the same type of soil and the rate is highest when all types of wastewater are discharged to septic tanks. The percolation test results confirm the previous studies by Siegrist (1987) that increasing the pre-treatment of domestic wastewater prior to soil application increases the soil absorption capacity.

As TOC contents of effluents decreases under Arrangements 2 and 3, the chances of soil clogging of soakage-pits would be less under these arrangements compared to Arrangement 1. Also, clogging at the infiltration surfaces were probably due to continuous inundation of the pits with effluents from septic tanks treating toilet wastewater only, as was observed by Laak (1970).

Table 5 shows the concentration of nitrate, total dissolved solid, phosphate and sulphate. These concentrations are higher than the standard specified by FEPA for effluent discharge into surface water except for phosphate. The higher concentration of nitrates in the raw wastewater may be attributed to urine and feces from toilets of Dan raka and Hayin dogo and also attributed to waste proteinous food and drinks from kitchen of these places.

The waste in wastewater contains proteins and to reduction of protein by bacteria. It may also be attributed to oxidation of various forms of nitrogen compounds like ammonia, nitrate in the presence of bacteria and oxygen. More also, phosphates concentration in the influent wastewater can be attributed to all types of washing activities in Dan raka, Hayin Dogo and New Extension which involves using detergent, soap, or other cleaning agents of phosphates as part of its component. Sulphate concentration as due to anaerobic reaction in the wastewater which generates hydrogen sulphide that ends up as sulphate compound.

Based on this study, it can be deduced that septic tank effluent quality varies significantly with the composition of domestic wastewater. For septic tanks treating wastewater from toilets only, effluent quality is poor. With the addition of kitchen wastewater, the effluent quality with respect to BOD,TDS, COD, TOC and SS improved significantly. For all-purpose septic tanks receiving wastewater from toilet, kitchen and bathroom, the effluent quality with respect to these parameters improved even further.

Removal efficiencies of FC, NO_3 and PO_4 however decreased with the addition of kitchen and bathroom wastewater primarily due to reduction in detention time. It should be noted that addition of kitchen and bathroom wastewater significantly increases wastewater volume to septic tanks resulting in higher initial costs. However, results from the study reveals that kitchen wastewater should not be discharged into open drains or surface water bodies as it contains high BOD, TDS, COD, TOC and TSS values in all three arrangements. They all decreased as detention hours increased from 24hours to 72 hours .

Also bathroom wastewater contains high amount of NO_3 and TDS although insignificant amount of other parameters. Results from percolation test reveals that, better quality of septic tank effluent enhances soil infiltration rates. This means that soakage-pits would require less area and would perform well for septic tanks treating kitchen and bathroom wastewater, in addition to toilet wastewater.

RECOMMENDATION

It used to be said that “the solution to pollution is dilution.” When small amounts of sewage are discharged into a flowing body of water, a natural process of stream self-purification occurs. However, densely populated communities like Samaru generate such large quantities of sewage that dilution alone does not prevent pollution.

Instead of discharging sewage directly into a nearby body of water, it’s better to let it pass through a combination of physical, biological, and chemical processes that remove some or most of the pollutants. This takes place in sewage treatment plants. Based on this study, the following suggestions can be made.

Table 5: Quality of Influent Wastewater In Open Drainage in Each of Three Selected Sites.

PARAMETERS	DAN RAKA	HAYIN DOGO	NEW EXTENSION
Temperature	48	431	52
Ph	7.33	6.90	6.67
Settleable solid(ml)	27	19	2
Total solid (mg/l)	1680	600	5000
Suspended solid(mg/l)	700	100	1100
Total dissolved solid(mg/l)	1980	1500	6900
lkalinity(mg/l $CaCO_3$)	170	30	20
Dissolved O_2 (mg/l)	1.30	2.60	1.30
Biological oxygen demand (mg/l)	180	120	230
Nitrate(mg/l)	2270	2210	7440
Phosphate (mg/l)	0.98	0	0.19
Sulphate (mg/l)	242	182	92

Source: field survey 2008

a. Sewage treatment plants should be built in the study area by the government. This will go a long way to neutralize and deactivate the chemicals found in the sewage water. They work by relying on the bacteria that is found in our colons, which eat away the nitrates, phosphates and organic matter that is found in sewage.

b. Although these plants can be expensive to build and operate for many governments, there are cheaper alternatives which is the building of septic tanks in more homes within Samaru. The more of these tanks that are built, the less wastewater finds its way into open drains in the study area.

c. State law should require that is septic system is installed in every new house built. Also, the installation must be approved by the health department before electrical service can be permanently connected to the house.

d. Since most houses in Samaru are already in place without septic installation, and with no provision for them, creating space for constructing new ones becomes a problem. The study suggests that a pit, in the form of a well, can be built along the drainage channel to trap wastewater. This can be constructed close to house. After digging, a PVC pipe can be connected from the house, into the pit and concrete cover or wooden cover can be place to prevent smell. (This recommendation is suggested by me in view economic situation in the study area).

e. Therefore, based on results obtained ,it is recommended that for effective and efficient design of septic tanks in the study area; one day detention time be used for tanks receiving toilet wastewater only ,and three days detention time be applied for the all purpose septic tank (Arrangement 3) and septic tank receiving both toilet and kitchen wastewater (Arrangement 2).

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