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Study of Safe Separation Distances between Rural Wells and Neighbouring Soak-Away Systems.

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Abstract

It is becoming increasingly common for educated Nigerians to build houses in rural and semi-urban areas of the country. The plan of a typical modern house includes construction of a septic tank and soak-away for disposal of wastewaters. Very often, a well is dug on the same plot of land for supply of water in lieu of tap water supply. If the homeowner knew that the soak-away system could contaminate his well-water, he might be able to arrange the structures so as to put a safe distance between his well and his soak-away unit. The study reported in this paper shows that in a silty sand soil, the safe separation distance is about 14 meters.

Introduction

Partly in response to the call by the Federal Government of Nigeria for increased agricultural activities and partly out of the felt need by Nigerian workers of all grades for a personal home-base to return to now and then, and upon retirement, there is an unprecedented wave of house-building activities in rural and semi-urban areas of Nigeria today.

The aspiring home-owner purchases or acquires a plot of land and has a plan drawn up, which includes housing structures and a septic-tank soak-away system for wastewater disposal. Of course, he would need water for bathing, cleaning, drinking, cooking and for flushing toilet. Many rural areas of Nigeria do not have the benefit of pipe-borne water, and to the extent that even the urban centres do not have enough, there is little hope for the supply of water to most rural areas. Thus, a common modification to the plan stated above is the construction of a hand-dug shallow well. In addition, many of these home-owners will most likely be involved in poultry keeping and vegetable gardening. Both activities require water and thus, the construction of shallow water wells is likely to be on the increase.

Whereas such variables as location, cost, most probable use etc., influence the decision to acquire a plot of land to build a house one, the question of soil type is not usually considered. Thus, a man who builds his house on a piece of land which is made up of fine clay soil is usually stuck with the problem of a soak-away system that just does not soak-away, but ozzes out of the top. This necessitates frequent desludging which is a very messy operation. On the other hand, a soak-away pit built in sand can spread its contaminating effect far and wide, even into nearby wells.

This paper reports findings of a study designed to determine the minimum separation distances that should be provided between soak-aways and neighbouring wells, and to relate these to soil characteristics.

General Background

A wastewater (sewage) is that liquid obtained when clean water has been subjected to various forms of use and abuse in homes, commercial outfits and in industries. Wastewaters from homes (domestic sewage) result from toilet flushing, culinary activities (Kitchen) and other home washing and cleaning functions. These liquids generally contain high concentrations of organic and nitrogenous substances which are natural constituents of foodstuff. When these substances are acted upon by micro-oranisms under uncontrolled conditions such as in open drains or gutters, they are putrefied and become offensive to see and smell. The degree of offensiveness is a function of the concentration of the putrescible matter in the wastewater and is generablly measured in terms of B.O.D. (Biochemical Oxygen Demand), which is the amount of oxygen that would be necessary for aerobic micro-organisms to reduce the putrescible components of the wastewater to a relatively inert or inoffensive matter.

Wastewaters from water closets invariably contain human excrement. They also contain large quantities of harmless micro-organisms, especially *Escherichia coli* which normally reside in the intestinal tract. In addition to *E. coli,* people suffering from diseases such as cholera, typhoid, infectious hepatitis and various forms of gastroenteritis, discharge the causative organisms of these diseases along with their faeces. Thus, a combination of organic, nitrogenous and pathogenic organisms in wastewaters, make it imperative that they should be collected, treated and disposed of in a sanitary manner.

Handling and Disposal of Wastewaters

Any house, commercial outfit, or industry with water closets and kitchen sinks must have a system of pipes (referred to as sewers) to take away the wastewaters (sewage). The network of sewers (the sewerage system) collects sewage from the house into a suitable treatment system.

Three broad sewage treatment systems may be identified as follows:-

1. Septic tank and soak-away-pit combination.
2. Oxidation pond.
3. Conventional treatment system, which may be
   (i) A trickling filter, or
   (ii) an activated sludge unit.

The conventional types (eigher a trickling filter or an activated sludge system, or a combination of both) represent the most efficient, and of course, the most expensive. Fig. 1 is a flow-through scheme of a standard treatment plant.

It is not intended in this presentation to give details of the processes involved in a trickling filter, or an activated sludge unit. They both operate broadly on a basic principle; namely, to provide a dissolved oxygen environment to micro-organisms which convert the putrescible components of the wastewater to feed themselves and grow. The primary sedimentation tank causes some settling, and sends the effluent to the secondary treatment unit where micro-organisms do their work, the final clarifier settles the remains of microbial conversion. Its effluent is often disinfected by chlorination prior to discharge to the stream. The five-day BOD (BOD_5) removal of a properly operated activated sludge or trickling plant may be as high as 90%.

The oxidation pond operates on a combined principle of biological oxidation and photosynthesis, and is much less expensive in terms of cost of design and construction. It is suitable where land availability is not a problem, as several hectares of land area are often required for it. The raw sewage is led into a prepared shallow pond, where oxygen is supplied to micro-organisms by natural aeration or by mechanical means. The effluent of the pond is also sometimes chlorinated prior to discharge to a stream. When properly designed and operated, the oxidation pond could be as efficient as the conventional plant. The real limitation is the excessive land area required.

A few institutions across the country now use one form or the other of the conventional treatment system to treat all or part of their waste-waters. The University College Hospital, Ibadan (U.C.H.) uses a trickling filter system followed by a mild form of activated sludge unit, the University of Ibadan uses a combination of trickling filters and activated sludge systems, while the University of Ife, uses the oxidation pond system. A plan for a central system of treatment plants for the city of Ibadan is also underway. However, the most common means of getting rid of spent waters in modern Nigerian homes today (apart from dumping them direct into gutters and ditches or using pit or bucket latrines, which are gradually fading out along with old, unplaned houses), is the septic tank soak-away-pit arrangement. Fig. 2 is a diagramatic representation of this treatment system.

The above system operates differently from those described earlier, the major difference being that no oxygen is used by micro-organisms in converting the putrescible components of the waste. The wastewater enters a septic tank and is settled. A group of anaerobic micro-organisms converts and stabilizes the obnoxious constituents of the wastewater; the effluent flows into a soak-away-pit (a pit filled with large size aggregate or broken sandcrete block) from where it soaks into the ground without any form of disinfection. This undisinfected effluent could contaminate groundwater.

Materials and Method

The study plan involved identification of a soak-away-pit, digging holes (with a hand-auger) at varying distances from it until water was reached, and taking both soil and water for laboratory analysis.

Since it was important that water be reached during the augering operation, it was necessary to select soak-aways located in relatively high water-table areas. Accordingly, some preliminary reconnaisance surveys were carried out. The soak-away-pits of a row of houses parallel to Road 2 at the University of Ife staff quarters were found to be very close to a small flowing stream and one of them was selected as the project site.

A plan of the project was marked on the ground as in Fig. 3. The numbered letters in the figure identify locations of augered holes in the directions indicated. For example, A1 represents a hole augered one meter away from the soak-away in the A-direction and so on. A topographic survey of the project area was also carried out. The contour lines (Fig. 4) show that the land slope was generally from NW to SE. This is probably why no water was encountered up to a depth of 2 metres along D,

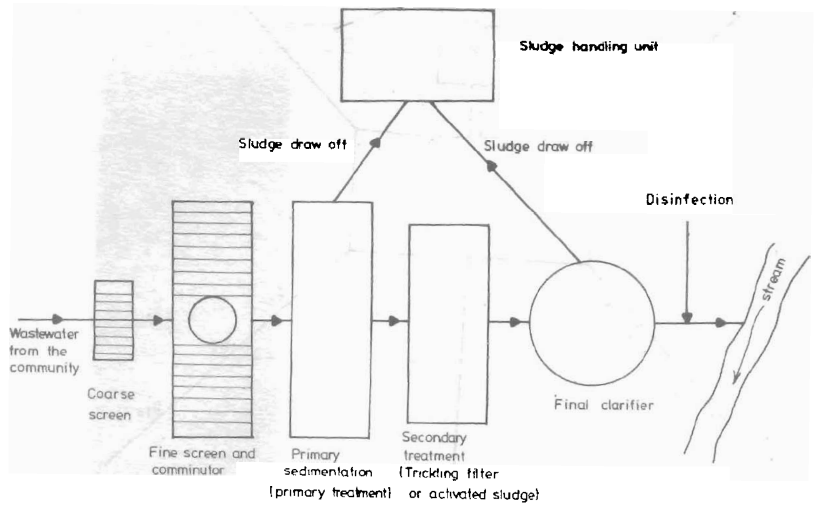

Fig. 1: Flow chart of a Conventional Wastewater Treatment Plant

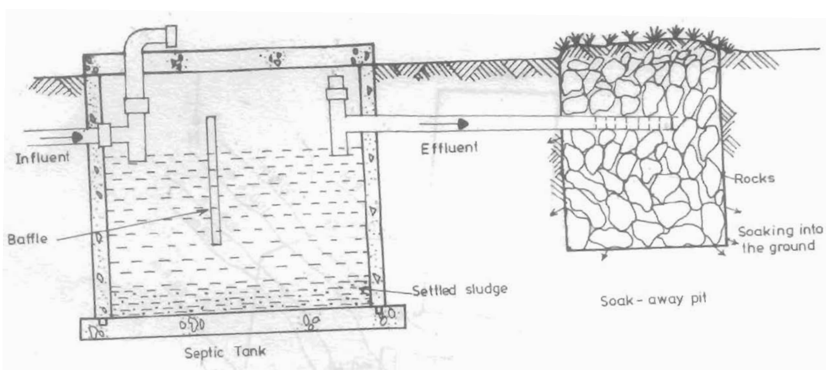

Fig. 2 : Cross-section through a septic tank and soak-away pit system

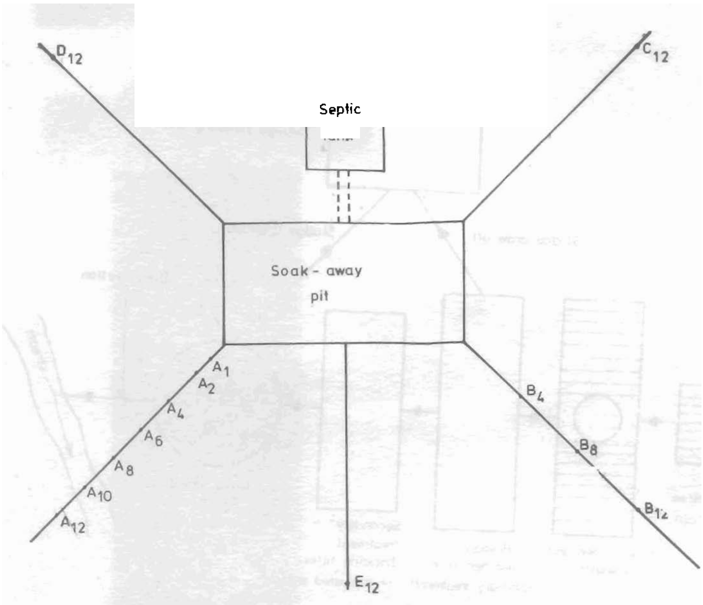

Fig. 3: A schematic diagram of the septic tank and soak-away system with the study bore-holes

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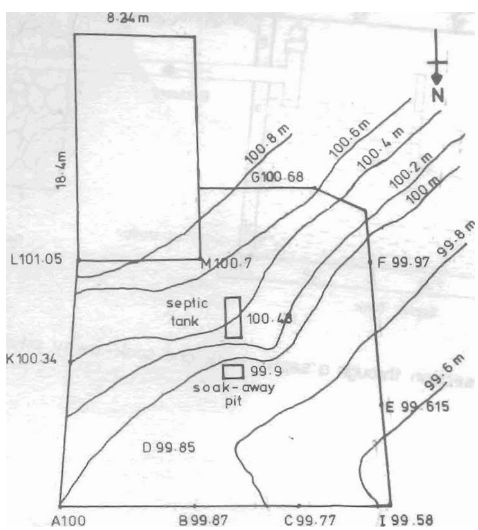

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Fig. 4: Topographic map of the project site

whereas the water table was generally reached at depths ranging from 0.5m to 1.0m in the other directions. Soil samples were taken from holes A1, A12, B4, and C2, and analysed in the laboratory. In each case, the percentages of sand, silt and clay were found to be 80, 12 and 8 respectively; and with the aid of a standard triangular classification chart, the soil was found to be in the silty-sand group.

Water samples were collected from each hole, and analysed for coliform count (as a measure of microbial contamination), chloride concentration, and BOD (Biochemical Oxygen Demand). Coliform concentration was determined by the multiple fermentation technique using the most Probable Number approach; BOD was determined by the 'dilution' method; and chloride concentration was determined by the Mercuric Nitrate method. All the tests were performed in accordance with the 'Standard Methods' (APHA, 1975).

Coliform count, chloride concentration and BOD were selected as the important measurable quantities for ascertaining the extent of travel of liquid content of soak-away-pit. The justification for these are as follows.

Coliform count: a measure of the number of *E. coli* – is used and over the world as an indicator of the degree of contamination of a given sample of water. It is an indirect method that indicates possible presence or absence of pathogenic organism. To the extent that only warm blooded animals discharge these organisms with their faeces and since the wastewater under study was of human origin, then their presence in the samples would indicate that elements of human intestinal discharges are present. If so, then any disease-causing germs excreted by inhabitants of the household or their visitors could be present. The World Health Organisation, and the American Public Health Service (APHA, 1965), as well as other World Standards require that the coliform count in water meant for human consumption do not exceed one coliform per 100ml of water. Thus, by measuring the coliforms in the samples from the augered holes, the degree of faecal contamination in each, could be ascertained. Of course, it should be mentioned that other organisms of soil origin (e.g., *Aerobacter aerogenes)* can, and do interfere with coliform counting. However, it is possible to run specific tests to isolate those coliforms of human origin from those of soil origin. This was done in this study.

The coliforms were qualitatively determined (as part of 'Confirmed' test) to be largely *E. coli* (of faecal origin) based on their characteristic appearance on Eosine Methylene Blue Plates, as dark tiny red with green metallic sheen.

Chloride: The use of chloride in this type of study is based on the premise that since humans are the only animals that consistently use salt in their food, presence of salt in large concentrations above and beyond what is normal in the particular soil, can be attributed to presence of human kitchen waste.

BOD: If the soil is normally low in organic and nitrogenous content, then presence of high concentrations of these substances – as measured by BOD – would indicate presence of human waste. The BOD is used all over the world as a measure of degree of water pollution (Demann, 1973; Sawyer and McCarty, 1967).

Results and Discussions

Coliform Densities

Table 1 shows the result of coliform counts obtained in the various directions. The number recorded in each row of the table represents a mean of 3 different runs. Differences in each set of 3 runs were found not to be significant at 5% confidence level. Because so many tests were made on each hole, the laboratory analytical work load was heavy. Consequently, direction A was the only one studied in great detail while selected points were studied in the other directions. -The land sloped generally in the direction of A, E, B and C, while D was on a high ground (Fig. 4). Consequently, it was not possible to reach the water table in the D-direction.

The results show the coliform counts to vary from 46,000 per 100ml at a distance of 1 meter from the edge of the soak-awya-pit to practically nothing at a distance of 14 meters in this particular soil. The 3 readings, B4, B8, B12 in B-direction show that coliform concentration in that direction was roughly the same as in A-direction. Reading E12 also roughly tallied with A-12. These points suggest that the contaminating effects along A, B, and E are similar.

BOD and Chloride Concentrations

The chloride concentration did not indicate any particular trend. It averaged about 22.5mg/l from hole A1, through hole A6 (Table 2). The five-day BOD (BOD_5) was generally close to 100mg/l from one hole to another irrespective of the direction (Table 2). Since the soil had no organic or nitrogenous components, the BOD was probably contributed by the waste. The fact that the value was essentially un-

TABLE 1 – COLIFORM DENSITY PER 100ml OF WATER SAMPLES AT VARYING DISTANCES FROM EDGE OF SOAK-AWAY-PIT IN DIFFERENT DIRECTIONS.

Distance from edge of soak-away-pit (metres)	*Average No. of Colonies per 100ml of sample (24 hours incubation)*				
	A	*B*	*C*	*D*	*E*
1.0	46,000	-	–	water table not reached	–
2.0	36,000	–	–	"	–
4.0	36,000	40,000	–	"	–
6.0	26,400	–	–	"	–
8.0	13,300	12,400	–	"	–
12.0	67	–	NIL	"	100
14.0	NIL	NIL	–	"	NIL

TABLE 2 – CHLORIDE AND BOD CONCENTRATION, IN WATER SAMPLES TAKEN AT VARYING DISTANCES FROM THE EDGE OF THE SOAK-AWAY-PIT.

Sample Point	*Average* Chloride Concentration (mg/1)*	*Average* BOD_5 (mg/1)*
A1	22.5	100
A2	22.5	85
A4	22 5	105
A6	22.5	Missed
A8	Not taken	
B4	Not taken	100
B14	Not taken	100

*Each value recorded for chloride concentration. is an average of 4 readings ranging from 21.67 to 23.0 mg/1; and for the BOD each value represents an average of 3 dilutions, the results of which in most cases were very close.

changed, could probably be interpreted to mean that the BOD was contributed by dissolved putrescible matter, the suspended components having been filtered by the soil; and that the dissolved components simply passed through the soil unaffected.

Additional Observation

After completion of work at the selected project site, an additional reconnaissance survey was made in the general area. The purpose was to set the stage for another study involving a different soil type. In the course of the survey, one soak-away-pit was found with the water oozing out at the top. The soil was identified (without any laboratory analysis) to be of fine clay. A hole was augered at a distance of 0.5m from the edge of the pit. No water was encountered even after augering to a depth of about 2 metres. This appeared to be a classic case of a soak-away-pit that just would not soak away. It also suggests that in the case of clay soil, the soak-away-pit need not necessarily be far away from the well since "soaking away" would be minial. However, the soak-away-pit would need to be considerably larger to reduce frequent desludging.

Conclusion

The following conclusions can be drawn from the result of this study:

1 In a soak-away system built in a silty sand soil, sloping at about 5%, the contaminating effect (especially in terms of coliform counts) does not appear to wear off until a distance of about 14 metres is reached.

2. Wells which must be located nearer than 14 metres to the soak-away in this soil (for lack of space) are not safe sources of water for human and livestock consumption unless the water is first boiled or otherwise disinfected.

3. If the plot of land is slopy, wells should be located upstream of soak-aways in which case a smaller separation distance could still be safe.

4. It appears that, where the plot of land is of the fine clay type, the soak-away-pit should be large enough to reduce the frequency of desludging operations, since the wastewater is unlikely to soak-away.

Acknowledgement

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References

Alpha, 1975. *Standard methods for the examination of water and wastewater* American Public Health Association, Inc. New York.

Demann, K.E. 1973. Drinking water or sewage: Is there a difference? *Univ. of Ife Inaugural Lecture ser.* 9.

Sawyer, C.N and McCarty, P.L. 1967. *Chemistry for Sanitary Engineers.* McGraw-Hill Book Co., New York.