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WATER, SANITATION, ENVIRONMENT and DEVELOPMENT

On-site sullage treatment

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Introduction

Droughts have become a common feature in Zimbabwe as was evidenced by the 1989 to 1991 drought that resulted in the country facing a severe food and water shortage. Most urban areas of the country source their water from surface reservoirs. During droughts these dwindle and local authorities find themselves having to ration the limited water available to ensure continual supply until the next rain season if it rains. Consumers have to limit their water usage.

This paper looks at the on-site treatment of sullage (kitchen, bath, and laundry wastewater) for re-use to supplement the rationed supply. Such effluent can be used for filling the toilet cistern, bath, swimming pool, car washing and watering the garden.

A research has been carried out and is still continuing at the University of Zimbabwe on this and the preliminary findings of this are discussed in this paper. The effect of reducing the water content of sewage by on-site sullage treatment on sewer hydraulics is also being evaluated and findings will be published soon.

The sources of sullage

Zimbabwe's residential housing set-up consists of three broad types.

a. High density housing catering for the most low and few middle income groups. A typical population is 10 persons per house.

b. Medium density housing catering for most middle and some high income groups. A typical household has about 7 persons.

c. Low density housing catering for most of the high and some middle income earners. Typical occupancy is 6 persons or less per household. Central Statistical Office, 1992).

The above housing set-ups are on the following average stand sizes:

High density - 500 square meters or less

Medium density - 1 acre or less

Low density - 1 acre or more

Water consumption per household is lowest for the high density areas at about 600l/hd/d. Medium housing residents require up to 1200 l/hd/d and the very affluent low density dwellers use up to 2000l/hd/d. (Stewart Scott NCL,1982)

From the foregone paragraphs, it can be assumed that the high density areas are not suitable for on-site sullage treatment because of the small areas, low water usage that will not generate enough sullage and also the high density population will most likely be a problem in disease control.

For the other two types of housing, where there is sufficient area and sullage, the on-site sullage treatment facility can be considered to be appropriate. Other establishments where this facility can be considered include schools, farmsteads and some industries. The generated sullage can be assumed to be about 80 to 85% of the water used. (Hammer MJ,1982)

The on-site sullage treatment facility

Process design

This treatment facility is based on the following design philosophies:

a. treatment facility unit to have little disruption or none to life and habits of users

b. construction of facility unit to be easy, simple, and affordable

c. facility unit to be easy to maintain and rehabilitate and it must be reliable

d. the unit must be economical in terms of capital and recurrent costs

e. treatment process must achieve the desirable physical, chemical and biological qualities permitting the various uses.

For re-use, the effluent must be:

a. clear, free of colour

b. odourless so as not to offend the user

c. pathogen free so as not to cause diseases

d. non-corrosive so as not to damage the delivery pipes and the utilities on which the water is used.

A combination of different treatment processes can achieve the above qualities.

Physical process
This involves the screening, sedimentation, and filtration processes.

Screening process
The screening process is intended to remove the solids that are too large and would otherwise clog the processes that follow. Ideally this consists of a screen of openings spaced at 5mm and the conventional cast iron gully suitable. This must facilitate physical handling to clear off the caught impurities.

Sedimentation process
This involves the settling of solids under quiescent conditions in a chamber that encourages the settleable solids to collect at the bottom and get desludged occasionally into the sewage disposal system. The floating scum can be skimmed off into the same disposal system . This process should remove about 35 % of BOD and 50% of suspended solids. (Hammer MJ,1982)

Filtration process
This process is intended to remove the non-settleable solids that pass through the preceding physical processes. A final filtration stage ensures the removal of micro size impurities such as colloids and bacteria . Whilst the former can take place through course to medium texture sand, the latter will take place through fine sand, microstrainers or ceramic filters.

The first filtration will initially act as a purely physical process that will ultimately involve the biological process as well.

The first filtration process must occur in a unit containing coarse sand layered over fine gravel which in turn sits on coarse gravel. A bottom abstraction facility must be incorporated. Recommended filtration rate is to be less than 2 cumecs per square metre day.

Biological process
This process involves the removal of pathogens within the biological zone developed in the first filtration process. This will come into operation after some while.

Chemical process
This process involves the killing of pathogens in the treated effluent using chemicals. Chlorine is the best chemical for this because of its solubility in water as a gas, liquid, and solid; its relatively cheap availability and its residual property.

The treatment processes to be involved in any treatment facility will depend on the following factors:

a. influent and effluent quality
b. influent and effluent quantity
c. technical feasibility of treatment plant
d. availability of chemicals, materials and spares
e. flexibility of layout
f. easy of operation and maintenance.

The required process arrangement for treatment will be as shown in figure 1 below.

Physical design

The treatment unit will consist of units that will enable the screening, sedimentation, filtration biological and chemical processes to take place. It will have a storage facility that will ensure a constant water supply at fairly constant residual head and flow. This will allow time for repairs and essential service and maintenance upstream of the storage without interrupting the flow. The storage unit can be buried or elevated in the roof. A pump is required to lift the water in both cases and such a pump can be manual or mechanical. The storage unit has got to be connected to all utilities where the effluent is to be re-used through an independent plumbing system.

Circular rather than rectangular shaped units are economical for such small plants. Factors such as density current control, surface skimming ,equipment maintenance and influent distribution which are better in the latter shape need consideration (Wastewater Pollution Control Federation, 1882).

Research work at the University of Zimbabwe

Research work has been carried out at the University of Zimbabwe in the Civil Engineering Department on the above topic . Preliminary results of the findings of this work are discussed below and specific average results of tested parameters are tabulated in Table 1.

screening → sedimentation →	filtration	→	irrigation (sub/surface)
	filtration	→	some uses
	chlorination		
	storage	→	all uses

Figure 1

Table 2 shows the treatment levels achieved by the individual processes and the combined processes.

The treatment unit for this research consisted of rectangular chamber units of 1 square meter area. A flow rate of one cumec per square meter per day was used on kitchen effluent dominated sullage. The experiment was carried out for a period of ten weeks. The average results over that period are the ones given in Table 1.

Advantages of on-site sullage treatment

On site sullage treatment achieves the following:

1. low water bill - no penalties for excess water usage.
2. greener gardens
3. cleaner people
4. on-site waste disposal system is smaller.
5. off-site disposal treatment works are smaller due to reduced sewage content
6. off-site sewerage system is smaller in size.

Conclusions

From the research done it can be concluded that on-site sullage treatment is possible of course with a proper design. High levels of treatment can be achieved by incorporating the various processes. High cost savings can be realised at both individual household level and national level since all the aspects dealing with the treatment and transportation of wastewater will be reduced in size.

References

Central Statistics Office Zimbabwe (Population Census 1992)

Hammer M J (Water & Wastewater Technology)

Stewart Scott NCL (Zimbabwe) (Office Design Manual 1982)

W/water Pollution Control Federation (Wastewater Plant Design Manual 1982)

Zimbabwe Gvt Notice 638 of 1972 (Public Health (effluent) Regulations

Table 1
Results of on-site sullage treatment

parameter	*raw sullage*	*sediment unit o/flow*	*filtration unit o/flow*
TS (mg/l)	6000	2700	2680
SS (mg/l)	1500	654	60
Colour (Hz)	50	33	15
Turbidty (NTU)	300	165	100
Odour	***	***	***
Appearance	cloudy foamy	clear foamy	clear foamy
chlorine (mg/l)	2	1.5	.8
Ammonia (mg/l)	5	4	.5
Phosphates (")	53	29	10
Calcium (")	50	91	67
Conduct (mS)	3	3	2.5
Chlorides	250	300	100
Nitrites	.5	.1	0
COD (mg/l)	3000	1200	425
BOD (mg/l)	250	180	170
E.Coli (/100ml)	0	0	0

* denotes strength of odour

Table 2

Treatment Efficiencies(%)

parameter	*sediment*	*filtration*	*overall*
COD	60	86	88
BOD	28	32	32
SS	56	96	96
TS	27	55	55
Turbidity	45	67	92
Colour	34	70	70