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ONSITE WASTEWATER DIFFERENTIABLE TREATMENT SYSTEM
(Aerobic Biodegradation of Toilet Wastes by Using Sawdust as a Matrix)

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1. INTRODUCTION.

The wastewater effluent from a household or group of household is made up of contributions from various appliances, such as WC, kitchen sink, wash basin, bath, shower, and washing machine. WC represents the highest contribution to the wastewater in terms of volume and load for five out of the six determinants, the exception being the nitrate. The kitchen sink is the most important appliance for nitrate production and second in production of COD_t, TSS and PO_4-P (1).

Traditionally, wastewater effluent from a household has been divided into two fractions, blackwater (toilet wastes) and graywater (kitchen sink, wash basin, bath, shower, and washing machine) (4).

Elimination of blackwater from the residential wastewater stream by using non-water carriage toilet will reduce the mass of COD, TSS, nitrogen and phosphorous in the remaining wastewater stream (graywater), thus allowing smaller treatment units.

In this paper, Onsite Wastewater Differentiable Treatment System (OWDTS), a new approach for OWTS, is proposed based on a differentiable management and treatment of household wastewater effluents. Three fractions have been differentiated, reduced-volume blackwater, higher-load graywater and lower-load graywater. Thus, three different treatment processes are required to each fraction.

Procedure adopted for current research (treatment of toilet wastes) is shown. In case of graywater, a sketch of treatment processes is pointed out.

2. ONSITE WASTEWATER DIFFERENTIABLE TREATMENT SYSTEM.

2.1. Traditional onsite wastewater treatment system.

Traditional OWTS can experience two types of failure (33):

1. Operational: where the system does not remove wastewater from the home.
2. Functional: where the system continues to remove wastewater but does not properly treat the water prior to discharge into the environment

The inappropriate use and disposal of wastes from OWTS can have a number of adverse impacts that would include: spread of disease, contamination of ground and surface water, degradation of soil and vegetation, decrease in amenity due to odors and insects, and potential litigation.

2.2. Onsite wastewater differentiable treatment system (OWDTS).

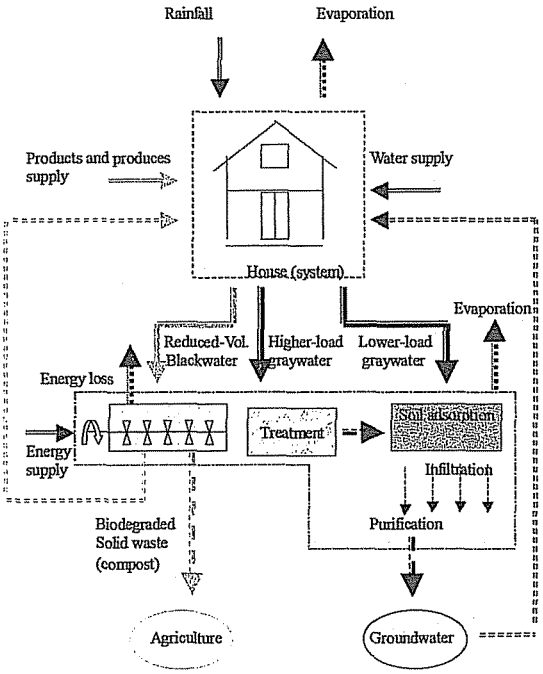

Figure 2.1. Hypothetical model for onsite wastewater differentiable treatment system.

The environmental and health principles supporting the management of onsite wastewater differentiable treatment system include: ecological sanitation, ecologically sustainable development, resources recycle (nutrients and water), water cycle management, total catchment's management, conservation of water resources, protection of public health and the prevention of public health risk (9).

Figure 2.1 shows a hypothetical model for onsite wastewater differentiable treatment system. In this system, the separation of household wastewater into three types is essential. Thus, reduced-volume blackwater, higher-load and lower-load graywater are new concepts that are intended to introduce in this model. Here, the treatment of blackwater conceives a change in the traditional way of using the WC; in other words, the use of water in the WC is thought just to clean the toilet, not to transport the toilet wastes; this is a very important change that it is possible by using a bio-toilet (dry-toilet).

The essential and new concept in the OWDTS is to treat separately the three fractions of household wastewater, see table 2.1. The importance of conceiving differentiable treatment for each fraction yields in the fact that:

1. *Blackwater* is practically eliminated from the household effluent by using the bio-toilet, it means, approximately 31% of fresh water will be saved, 44% of organic load, 97% of NH_3-N, 80% of PO_4-P, and 77.4 % of TSS will be eliminated from the household effluent.
2. *Lower-load graywater* could be treated by utilizing the natural capacity of soil microorganisms due to its pollution concentration was found to be 210 to 501mg/l (1).
3. *Higher-load graywater* with a pollution concentration of 1079 to 1815 mg/l represents 29% of household effluent that needs any conventional treatment process

for reaching acceptable quality (1).

On the other hand, bio-toilet is the name of a dry closet (DC) or composting toilet (CT). Bio-toilet is a non-water carriage toilet that uses natural biological decomposition to transform wastes (feces, urine and toilet paper) into a relatively dry, nutrient-rich humus material called compost.

Table 2.1. Contribution of each appliance for the daily total discharge volumes and pollutants loads (% of total volume or mass per 100 capita).

Appliance	Type of water	Volume	COD_t	NH_3-N	NO_3-N	PO_4-P	TSS
WC	Blackwater	30.8	43.9 (44)	97.1 (97)	3.8 (4)	79.8 (80)	77.4 (77)
Kitchen sink	Higher-load graywater	13.0	23.2	0.3	38.0	9.4	10.1
Washing machine		16.2 (29)	22.3 (45)	1.2 (1.5)	7.6 (45)	4.3 (14)	4.0 (14)
Wash basin	Lower-load graywater	12.6	1.7	0.1	10.7	1.3	2.1
Bath		15.7	2.5	0.6	15.3	1.1	1.3
Shower		11.7 (40)	6.4 (11)	0.7 (1.4)	24.6 (51)	4.1 (6)	5.1 (9)
Total (per 100 capita per day)		10.23 m^3	11188 g	237.95 g	36.72 g	668 g	5610 g

Adapted from (1). Values in brackets are percentages per type of fraction of wastewater.

2.3. Benefits of using an OWDTS.

The benefits of using an onsite wastewater differentiable treatment system (OWDTS) may be analyzed from the viewpoints of water and soil contamination prevention, conservation of resources, reduction of health risk for population, and economics. Such benefits may be the following:

1. The sources of pathogens, mainly toilet wastes, are eliminated from the wastewater stream, therefore, the groundwater contamination risk is reduced considerably.
2. The toilet wastes are converted in a stable organic matter source, probably free of pathogens, that may be recycled into the household when a garden area is available or be disposed in external systems such as urban green areas or agricultural land.
3. The reduction of blackwater volume is positive since allows the saving and conservation of fresh water (probably drinking water) conventionally used in toilet flushing and the reduction of wastewater flow rate to be treated.
4. Utilization of the natural capacity of soil organisms to biodegrade a fraction of the graywater organic load.
5. Reduced volume of graywater to be treated by conventional treatment processes, therefore, small size of treatment facilities, easier operation, and lower operation costs.
6. Safety and healthy disposal of treated wastewater into the soil and probable reuse of groundwater for the household and urban consumption.
7. Recuperation of static and dynamic groundwater levels in urban zones where

groundwater is an important source for water supply. This fact is important from two points of view, the pumping costs and the structural stability of soil and urban infrastructure.

8. "Zero wastewater discharge" into the centralized sewer system.

3. AEROBIC BIODEGRADATION OF TOILET WASTES BY USING SAWDUST AS A MATRIX.

Although, bio-toilet is commercially available, no qualitative and quantitative data of the biodegradation processes (reaction kinetics) occurring in the sawdust matrix are available. This fact reveals the significance of carrying out a research on this concern that contributes in the proper planning, design, installation, operation and maintenance of OWDTS, when the bio-toilet is used to eliminate blackwater and nutrients, especially nitrogen and phosphorous , from the household wastewater stream.

3.1. Physical and chemical properties of sawdust.

The benefits of using the sawdust matrix are derived from its inherent characteristics: high porosity, high void volume ratio, high water and air retention, high drainage, high bacterial tolerance, low apparent density, and biodegradability (25).

3.2. Kinetics of aerobic biodegradation of toilet wastes by using the sawdust.

Kinetics describes the rates at which phenomena (biodegradation) occur. There are four major factors influencing the rate of biodegradation (5).

a) Microorganisms (number, type).
b) Substrate quantity and bioavailability (composition, lignin content, particle size, etc.).
c) Nutrients, macro (N, P, K, S) and micro (Mg, Co, etc.).
d) Environmental conditions (moisture, porosity, temperate, oxygen, pH).

4. CONCLUSIONS.

1. Considering the actual tendencies towards ecological sanitation in recycling society and the pressure on the world's water resources, the OWDTS seems to be a new approach with higher potential for improvement of traditional OWTS, dry ecological sanitation, recycle of resources (toilet wastes and water), conservation of water resources, etc.
2. Aerobic biodegradation of toilet wastes by using sawdust as a matrix is an essential treatment process of the OWDTS. Several contributions may be derived from this research.
3. Natural biodegradation of lower-load gray water by soil bacteria needs to be deeply studied, and proper treatment system for higher-load graywater must be selected.

5. CURRENT RESEARCH.

The main objectives of the research under performance are listed below:

a) Qualitative and quantitative description of the processes' kinetics of the aerobic biodegradation of toilet wastes using sawdust as a matrix.

b) Establishment of mathematical model to describe the kinetics of aerobic biodegradation of toilet wastes using sawdust as a matrix.

c) Development of criteria for the proper design and operation of toilet wastes treatment systems using sawdust as a matrix.

The figure 5.1 summarizes the steps, methods and procedures thought to achieve the above objectives. Actually, optimum environmental conditions (toilet wastes – sawdust ratio, temperature, moisture content, and oxygen supply) are under study.

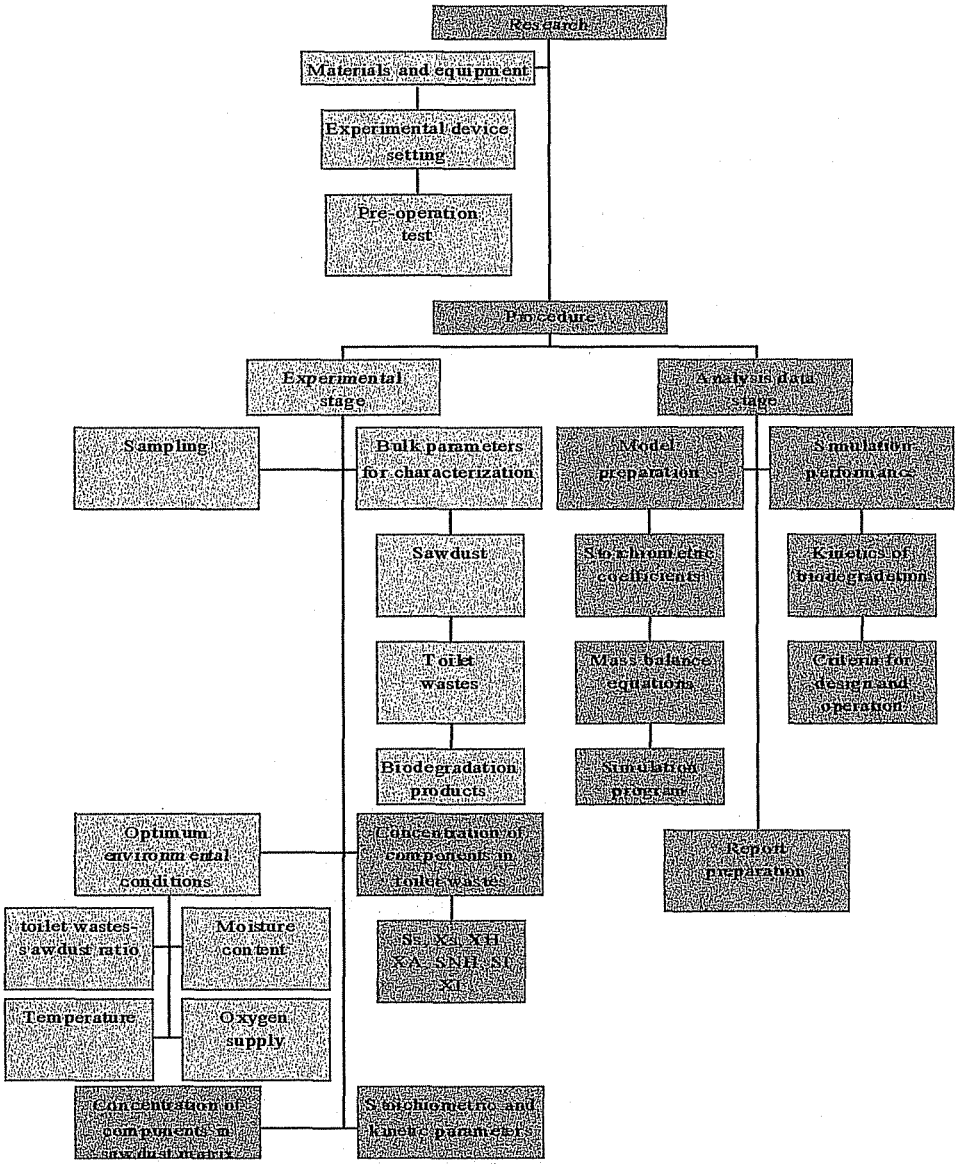

Figure 5.1. Flowchart that summarizes the research methodology.

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