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Faecal Sludge Management and Appropriate Technology for Faecal Sludge Treatment- A Review

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Abstract -*The primary objective of this study is to identify the issues due to faecal sludge or septage issues in villages and cities, effects on water bodies, resources, human being and other species like animals, birds and water animals. In many countries, the large numbers of septic tanks have been constructed in rural and urban areas recently but as there is no faecal treatment facility provided. Also identify the appropriate low cost and eco-friendly technologies available in market for treating the faecal sludge or septage and reduce or avoid spreading diseases and control Environmental Pollution.*

Key Words: Faecal Sludge Management, Septage, Treatment, Water Bodies, Villages and Cities, Vermifilter, Earthworm, Tiger Biofilter

1. INTRODUCTION

Use of toilets is sometimes equated with sanitation; however, it is important but not the sole solution to all problems and problems related to sanitation. How the waste is handled after it has been flushed plays a significant role in sanitation. A complete sanitation value chain includes the handling and disposal or by-product reuse of waste in along with toilet access. After flushing, waste that is not managed properly or that is not processed and disposed of correctly could end up contaminating soil and water sources, creating serious environmental and health risks. Unsafe drinking water and sanitation practises are directly linked to an increase of diseases like diarrhoea. Lack of access to safe drinking water and fundamental sanitary facilities is responsible for 90% of all diarrhea-related deaths in India, especially among youngsters. To guarantee a healthy water supply for the populace, effective collection, treatment, and disposal are essential.

1.1 Aim of Study

The aim of this study is to identify and understand status of current scenario of Faecal Sludge Management.

1.2 Objective

1. To understand current status of Management of Faecal Sludge worldwide.

2. To investigate characteristics of Faecal Sludge or Septage

3. Appropriate low cost and eco-friendly technologies for treat Faecal Sludge scientifically.

2. Literature Review

A review of the literatures consulted for the study is included in this section.

2.1 Planning faecal sludge management systems: Challenges observed in a small town in southern India

Author- Reeba Devaraj et.al. 2021

In this research paper highlights that, in order to scale up urban sanitation systems and offer safe sanitation, particularly in small towns and cities, faecal sludge treatment or septage management is increasingly recognised as a viable and appropriate technology. As implementation moves forward, data-based evidence is surfacing that shows the local issues and the necessary strategy to solve them.

This study was done to gather information for Faecal Sludge Management (FSM) planning for a small town in a state in southern India. The study's findings, difficulties, and potential solutions are presented in this report. 8,001 households and 1,667 establishments in Periyanaicken-Palayam (PNP), a non-sewered Town Panchayat in Coimbatore District, Tamil Nadu, were studied with the goal of understanding the nature of containment structures and on-ground desludging practises in order to provide evidence for efficient decision-making.

The study showed significant variation in containment system sizing and design, which, when combined with irregular desludging frequency, has an impact on FSM planning by local bodies. Due to the underground nature of these systems, it is difficult to physically verify the reported data, which raises methodological issues with studying containment systems. It also reveals a significant response bias given the limited understanding of containment systems in households.

2.2 Vermicomposting Technology for stabilizing the sewage sludge from rural waste water treatment plants

Author- Lina Cardoso V et.al. 2008

In this research paper mentioned that, due to costly conventional methods for sludge stabilisation, there are issues with sludge management in small treatment plants in rural communities. Many of these plants only have beds for drying sludge. A vermicomposting system that uses earthworms of the species Eisenia foetida, which stabilise sludge and reduce its harmful effects, has been recommended by the Mexican Institute of Water Technology as one of the low-cost technologies that should be developed. This project's goal is to present two examples of vermicomposting technology being used in Mexico.

The first research relates to a facility that produces 4.8 m3/month of sludge; a vermicomposting system was developed and installed to handle these wastes. In the second phase, experimental studies were carried out using sludge and water hyacinth, and a vermicomposting system was constructed. This treatment facility produces 9 m3/month of sludge. Mexican standards-based metrics were used to analyse the vermicomposts.

TVS was reduced by 38% in terms of stabilisation, and the vermicompost's microbiological quality was Class A and B with a reduction in faecal coliforms and Helminth eggs. The method decreased the concentration of releasable sulphides, as demonstrated by a Corrosivity, Reactivity, Explosivity, Toxicity and Ignitability examination. The vermicompost's agronomic qualities included a high level of organic matter that was comparable to that of many organic manures and a high level of nutrients like nitrogen and phosphorus.

It is concluded that, with a minimum investment of less than $10,000 and a requirement of a minimum area of 60 to 70 m2 for a production of less than 9 m3/month of dehydrated sludge, the conditions of sewage sludge management in small plants of rural communities can be improved.

2.3 Sewage treatment by vermifiltration with synchronous treatment of sludge by earthworms: a low-cost sustainable technology over conventional systems with potential for decentralization

Author- Rajiv K. Sinha et.al. 2008

In this research paper highlights that, using the general mechanism of "ingestion" and "biodegradation" of organic wastes, heavy metals, and solids from wastewater as well as by their "absorption" through body walls, earthworms have been found to remove the 5 days' BOD (BOD5) by over 90%, COD by 80-90%, total dissolved solids (TDS) by 90-92%, and the total suspended solids (TSS) by 90-95% from wastewater.

By granulating the clay particles, earthworms increase the hydraulic conductivity and natural aeration. Also, they grind the silt and sand particles, increasing the total specific surface area, which improves the capacity to 'adsorb' the organic and inorganic from the wastewater. The earthworms' aeration of the soil and the intensification of soil processes make the soil stabilisation and filtration system more efficient and more compact.

Earthworms process the suspended materials and feed them to the soil bacteria immobilised in the vermifilter, which is topped with a trap for them. No sludge is formed during the process, eliminating the need for further landfill disposal costs. This procedure is also odourless, and the vermifiltered water that is produced is clean and disinfected enough to be used for farm irrigation as well as in parks and gardens.

2.4 Assessment of two faecal sludge treatment plants in urban areas: Case study in Beijing

Author- Cheng Shikun et.al. 2017

In this research paper highlights that, Around the world, a human excretes every day, and the sludge that accumulates into waste disposal systems is known as "faecal sludge (FS)". In cities, FS may severely pollute the environment if it is not properly disposed of. On-site sanitation methods, FS collection and delivery, a treatment facility, and resource recovery or disposal of the treatment by-products are all required components of a full FS management system. Two cases of FS treatment in Beijing are highlighted in this study, which focuses on the treatment and reuse/disposal stage of an FS entire service chain.

In Case 1, the FS biogas plant uses anaerobic digestion (AD) to treat the FS, and the digestate can be used as biofertilizer in the surrounding greenhouse. In Case 2, a variety of technologies, including dewatering, pyrolysis, AD, and co-composting, are combined to identify novel FS treatment methods. For additional SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, a thorough examination that takes into account the characteristics of technology, economy, and environment is undertaken. Critical strategies are then created, such as

1. selecting project site for optimized transportation, maximum waste reuse, minimum environmental impact and convenient final effluent disposal

2. planning technical options at a feasible study stage, considering resource recovery, secondary pollution prevention and fire protection
3. exploring market channels for by-products sale to increase profitability
4. guaranteeing engineering quality and service life for the purpose of sustainable operation
5. minimizing health risks to persons exposed to the untreated FS
6. providing necessary training for hygiene protection.

The Beijing cases can teach urban areas in developing nations important lessons, and the strategies may act as a guide for stakeholders and decision-makers who want to create FS treatment programmes.

2.5 Optimization of faecal sludge processing via vermifiltration

Author- Enrique Hernández et.al. 2017

In this research paper highlights that, before it can be discharged into the environment safely, faeces need to be treated. There is a need for more research into innovative treatment techniques like vermifiltration. In addition to examining the impact of bedding materials (woodchip, granular activated carbon (GAC) + woodchip, and clay pebbles + woodchip) on nitrogen reduction in the effluent, this study aims to determine if a simple vermifilter containing Eisenia Foetida can process sludge.

Although nitrification was not observed, all bedding materials performed excellently in terms of general effluent quality. This was believed to be the result of sampling and analytical methods. Seeing the decrease in worm population, the GAC bedding was inadequate. The best bedding material was woodchip, which produced the most vermicompost, solids conversion, and worm and cocoon densities.

This study shows to the discussion of nitrification in these systems by showing that Eisenia foetida can handle sludge in a simple vermifilter.

2.6 Faecal sludge treatment by vermifiltration: proof of concept

Author- C. Furlong, 2015 et.al. 2017

In this research paper, the objective of this research was to find out whether composting worms and their cocoons could live in and digest faeces. A total of 18 vermifilters, each with a different worm and cocoon density, were set up, run for 38 days on faeces sludge from portable pour-flush toilets. Analysis of the pH, total solids, chemical oxygen demand, faecal coliforms, and the number and viability of Ascaris spp. was done on samples of the sludge, effluent, and vermicompost.

At the conclusion of this time period, worm and vermicompost mass as well as cocoon counts were evaluated. The composting worms were found to survive in these circumstances and to hatch from their cocoons. The present research raises concern on the accuracy of the sludge analysis results because without them, solids conversion and effluent treatment could only be estimated.

This study has demonstrated that worms can turn faecal sludge into vermicompost and that cocoons can hatch in its presence, even though it was not entirely convincing. In India, this trial was conducted by author.

2.7 intentions toward Fecal Sludge Management in Rural Developing Communities

Author- James Harper et.al. 2018

In this research paper, 3.4 billion people use pit latrines worldwide, but little is known about how to safely and efficiently manage full pits in situations where human behaviour has a significant impact on outcomes. To preserve access to better sanitation services and continue to enhance public health, the urgent challenge of safe and effective faecal sludge management (FSM) must be tackled; doing so will involve taking into account how human behaviour influences FSM. This study examines the behavioural intentions of rural latrine owners towards FSM through the lens of the Theory of Planned Behaviour, describing a significant and understudied aspect of human decision-making that can be used to predict behaviour related to FSM and enhance the design of latrines and FSM procedures and training.

In order to determine how rural latrine owners, intend to handle their faecal sludge, survey data gathered from 3720 families in rural Cambodia between 2014 and 2017 were examined using frequency analysis, metrics of association, and binomial logistic regression. According to the findings, most owners of rural latrines (59%) plan to manage their faecal sludge in a safe and efficient manner; however, the remaining latrine owners (41%) expressed unfavourable FSM intentions, highlighting the rising risk to public health from ineffective FSM.

According to the Theory of Planned Behaviour, which connects individual, societal, and physical contextual factors to the formation of behavioural intentions, it was discovered that a number of contextual factors, including location, the date of the data collection, poverty level, past defecation behaviour, and satisfaction with the household's latrine and its supplier, significantly influenced FSM intentions. The desirability of FSM intentions could be predicted with 67% accuracy by a model that used these contextual parameters as inputs. Future work and restrictions are discussed. The foundation for future research into understanding FSM behaviours, developing FSM behaviour modification strategies, and creating safer and more efficient FSM processes for rural communities is laid out in this formative study of a human behaviour aspect that affects FSM.

2.8 Vermicomposting as an Alternative Method of Sludge Treatment

Author- Dariusz Boruszko, et.al. 2020

In this research paper, the findings of research conducted over a number of years using vermiculture plots in the Zambrów municipal wastewater treatment facility. Since 2004 (for 16 years), it has been the only facility in Poland producing vermicompost from municipal sewage sludge continuously. A simple statistical analysis was performed on the results of 32 tests of pre-made vermicomposts that were undertaken twice a year on a regular basis. The analyses of organic content, heavy metals, biogenic chemicals, and a few selected macroelements in vermicompost were compared to the specifications for mineral-organic fertilisers.

The results of the research undertaken support the use of California earthworms in the vermicomposting of municipal sewage sludge, which results in vermicompost that may be a valuable mineral-organic fertiliser due to its good humification and mineralization.

2.9 Technical and user evaluation of a novel worm-based, on-site sanitation system in rural India

Author- C. FURLONG et.al. 2020

In this research paper highlights that, A unique on-site sanitation system based on vermifiltration was tested in rural India for more than a year to determine its technical performance and user acceptability. A pour flush toilet connected to a vermifilter, together termed as a "Tiger Toilet," was tested by ten households that had previously practised open defecation. The following technical factors were monitored during this time: use, temperature, faeces and vermicompost accumulation, worm presence, influent and effluent quality. Through focus groups and comparisons to a baseline survey, user satisfaction was assessed. In a practical setting, the vermifilters efficiently processed waste products derived from people.

After a year, there was a 0–10% surface coverage accumulation of faecal solids and good effluent quality, with a 57% reduction in chemical oxygen demand and a 99% reduction in faecal coliforms. Vermicompost accumulation was low, indicating that only every five years would emptying be required. High levels of user satisfaction were reported, with 100% of respondents rating the "Tiger Toilet" as either extremely satisfied or satisfied. The use of worms and the absence of odours were cited as the key justifications.

2.10 The Tiger Toilet: From Concept to Reality

Author- C. FURLONG et.al. 2014

In this research paper highlights that, an innovative on-site sanitation solution based on vermifiltration called the "Tiger Toilet" is in the early phases of technological validation. It expands on previously published laboratory research that demonstrated the feasibility of wet vermifiltration for the treatment of faecal waste, and it reports on additional laboratory testing to identify important operational parameters that allowed the development of full-scale human-use prototypes. Worm density, feed distribution, system layout, and water loading were some of these variables.

Later prototypes were installed for household usage in rural India after the first prototype was constructed in the UK under somewhat controlled environments. The important findings were the quick and nearly complete digestion of faecal materials and the delayed accumulation of the resulting vermicompost. The performance at full size in field experiments and in the UK, prototype was generally similar with the lab results. The effluent quality in field prototypes was better than in laboratory tests in absolute terms.

These results support the promise of vermifiltration as a highly cost-effective, low-maintenance method of treating faeces that is suitable for usage in developing countries.

2.11 The development of an onsite sanitation system based on vermifiltration: the 'Tiger Toilet'

Author- C. FURLONG et.al. 2015

In this research paper describes that, the development of the "Tiger Toilet," a unique on-site sanitation technology based on vermifiltration. A 2 kg/m2 worm density could be employed, worms favoured moister surroundings, and system layout had no effect on the effluent quality, according to early laboratory trials. The first prototype was installed in the UK, and this demonstrated that the procedure worked when scaled up because the results for chemical oxygen demand and thermotolerant coliform reduction were found to be comparable to those obtained in the lab.

After being put to the test by ten houses in rural India, all ten prototypes were found to be functional after six months. Faeces weren't building up because the vermifilters were handling the daily amount that was entering the system. According on the depth of the vermicompost produced, they would need to be emptied after around five years. In comparison to other established sanitation systems, it is thought that the Tiger Toilet has the potential to advance with more development.

2.12 Processing of human faeces by wet vermifiltration for improved on-site sanitation

Author- C. FURLONG et.al. 2014

In this research paper describes that, it was studied whether human waste might be broken down in a continuous wet system using a vermifilter containing Eisenia foetida. Understanding the production of vermicompost inside the system, the quality of the effluent produced, and the impact of various bedding materials

were the objectives of this work. Four different bedding materials were used to build eight filters; four of these systems known as vermifilters were seeded with 400 g of worms while the other two acted as controls. The experiment was divided into five phases, each with a distinct feeding schedule, and the systems were flushed with 12 litres of water every day. Fresh human faeces were added to the vermifilters between 23.7 and 24.7 kg over the span of the 360-day period.

The average faeces reduction in vermifilters increased to 96% in the presence of the worms, compared to 38% in control systems. All vermifilters' effluent had phosphate, COD, and thermotolerant coliform reductions that were statistically significant. A coir and woodchip mix were the best bedding matrix. This study demonstrates the possibility of treating human waste continuously in on-site, moist vermifilters.

3. CONCLUSIONS

Based on the literature review, vermifiltration technology is suitable from others to treat faecal sludge by scientifically and for getting better result as well as to reduce environmental pollution and avoid water and soil contamination occurs due to faecal matter.

Eisenia Foetida worm species performs very well as compared to other species to treat faecal sludge and converted into vermicompost as a byproduct which can be reuse for gardening or farming purpose.

Tiger Biofilter is novel technology based on vermifiltration process and used Eisenia Foetida worm species for treat the faecal sludge. Also, Tiger Biofilter Technology is Unique, Low Cost, Natural, Sustainable and Eco-Friendly, which is appropriate and suitable technology to treat faecal sludge properly and converted into Vermicompost.

Currently Swachh Bharat Mission Programme runs in India and under this Programme, the Government is focused to treat liquid, solid and faecal waste at rural as well as urban areas to keep country clean and safe.

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