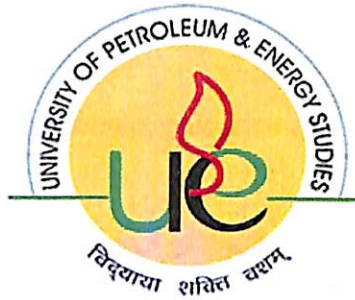




BIO-TOILETS:-A GREEN CLEAN ALTERNATIVE OF
SEWAGE TREATMENT PLANT IN POWER PLANTS

By

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Guided By

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UNIVERSITY OF PETROLEUM & ENERGY STUDIES, INDIA

CENTRE FOR CONTINUING EDUCATION

UNIVERSITY OF PETROLEUM & ENERGY STUDIES, DEHRADUN

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Declaration by the Guide

This is to certify that the Mr. SUDEEP, a student of (MBA-POWER MANAGEMENT), Roll No 500025513 of UPES has successfully completed this dissertation report on "Bio-toilet:- A green clean alternative of Sewage Treatment Plant in Power Plants" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA.

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EXECUTIVE SUMMARY

Sewage is a water-carried waste, in solution or suspension, which is intended to be removed from the system. Also known as domestic wastewater, it is more than 99% water and rest is organic (from sinks, showers, human waste, soaps and detergents). The sewage due to its polluting nature needs to be treated to the stipulated norms before it can be discharged to the environment.

In a power plant, Sewage Treatment Plant consists of collection of sewerage from various buildings of the power plant and transferring the same to a sewage treatment system. After treatment of sewage, the treated water generated is disposed to nearest drain or used into horticulture as per customer's requirement. However present environmental norms formulated by agencies like MOEFF (Ministry of Environment and Forests), CPCB (Central Pollution Control board), SPCB (State Pollution Control board) w.r.t treated water quality makes it imperative to treat the waste efficiently and dispose it off in an environmentally friendly manner.

At present most of the power plants are following the age old technology of conventional aerobic treatment system and soak pits / septic tanks for building not connected to central sewage system. However, with rising concerns as regards to ground water pollutions newer power plant are going in for other alternative like anaerobic treatment technique due to their effectiveness.

The new technology of Bio-Toilet is a complete waste management solution which reduces solid human waste to Bio-gas and clean water, with the help of a bacterial inoculum. Clear water generated from Bio-Toilet meets the various environmental norms . Thus Bio-toilets will help to create an eco-friendly alternate technology.

1.0 INTRODUCTION

Sewage is a water-carried waste, in solution or suspension, which is intended to be removed from the system. Also known as domestic wastewater, it is more than 99% water and rest is organic (from sinks, showers, human waste, soaps and detergents). The sewage due to its polluting nature needs to be treated to the stipulated norms before it can be discharged to the environment.

Sewage treatment is the process of removing contaminants from wastewater. It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent). A by-product of sewage treatment is usually a semi-solid waste or slurry, called sewage sludge, that has to undergo further treatment before being suitable for disposal or land application.

In power plants sewage is generated mainly from buildings, toilets, canteens and other utilities. After treatment of sewage, the treated wastewater generated is disposed to nearest drain or used for horticulture as per customer's requirement. However various environmental norms formulated by agencies like MOEFF (Ministry of Environment and Forests), CPCB (Central Pollution Control board), SPCB (State Pollution Control board) w.r.t treated water quality have to be met which in itself is a very difficult and tedious work.

At present most of the power plants are following the age old technology of conventional aerobic treatment system and soak pits / septic tanks for building not connected to central sewage system. However, with rising concerns as regards to ground water pollutions newer power plant are going in for other alternative like anaerobic treatment technique due to their effectiveness. The cost attached to these treatment technique acts as a deterrent.

The new technology of Bio-Toilet is a complete waste management solution which reduces solid human waste to Bio-gas and clean water, with the help of a bacterial inoculum. Clear water generated from Bio-Toilet is colorless, odorless, pathogen free and devoid of any solid particles and in turn meets the various environmental norms formulated by agencies like MOEFF (Ministry of Environment and Forests), CPCB (Central Pollution Control board), and SPCB (State Pollution Control board) guideline.

2.0 OBJECTIVE OF THE STUDY

The main objective of the study was to explore new methodology as an alternative to conventional sewage treatment plant which would be efficient, economical and takes care of the sludge disposal issues at the same time addressing the environmental conditions laid down by the agencies. The alternative technology selected should also resolve additional auxiliary power and pumping of sludge issues.

3.0 PRESENT PRACTICES FOLLOWED IN POWER PLANTS

Existing common practice followed in the field of Sewage Treatment Plant for a power plant are:-

A) Conventional aerobic treatment system for the main power plant.

Conventional Aerobic Treatment System treats sewage using air and biological floc composed of bacteria and protozoa. This reduces the BOD (Biological Oxygen Demand) of waste but the process is ineffective in removal of pathogens. Further the process involves aeration in large tanks and hence operation and maintenance is difficult and expensive. The process also produces large quantity of sludge. A conventional aerobic treatment system consist of the following procedure:-

- ❖ Preliminary Treatment:
 - Coarse Screens for screening incoming sewage
 - Oil & Grease Trap
 - Equalization cum holding tank
- ❖ Aeration System:
 - Aerobic Biological treatment in the FAB Tank with fine bubble diffused aeration
 - Transfer of treated partially treated sewage to the Clarification system.
- ❖ Clarification System:
 - Settling of digested sludge in the Tube Settler
 - Transfer & storage of clarified water to the Hypo Contact Cum Filter Feed Tank
 - Dosing of Sodium Hypochlorite in the Hypo contact Cum Filter Feed Tank
- ❖ Sludge Handling System:
 - Transfer of sludge to the sludge sump from the aeration tank & clarifier
 - Transfer of sludge to filter press/centrifuge
 - Transfer of concentrate or filtrate to the equalization tank.
 - Disposal of sludge as cakes by sludge trolley.
- ❖ Tertiary Treatment:
 - Polishing of treated sewage by DMF& ACF.
 - Transfer of Polished sewage water for horticulture.

Primary Sewage Treatment

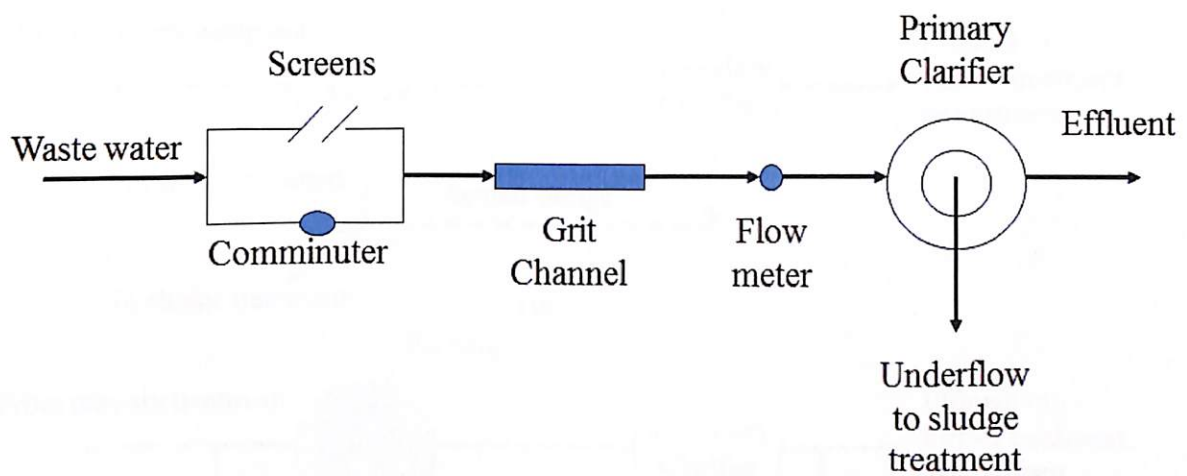


FIGURE: 1

Secondary Sewage Treatment

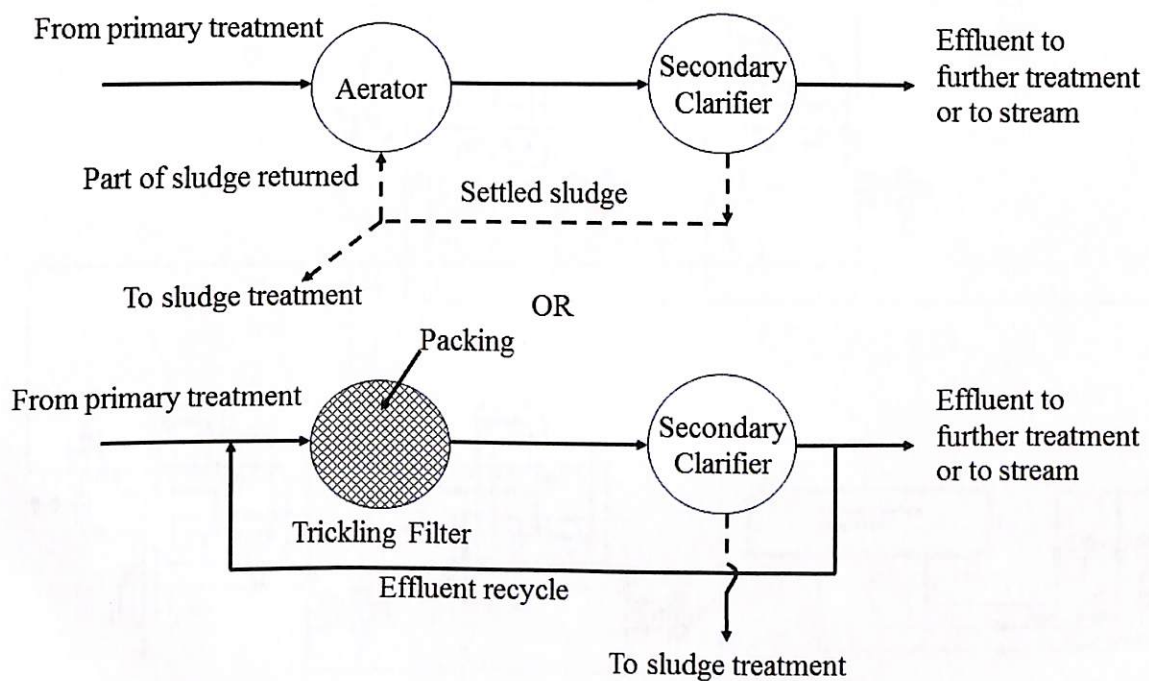


FIGURE: 2

Tertiary Sewage Treatment

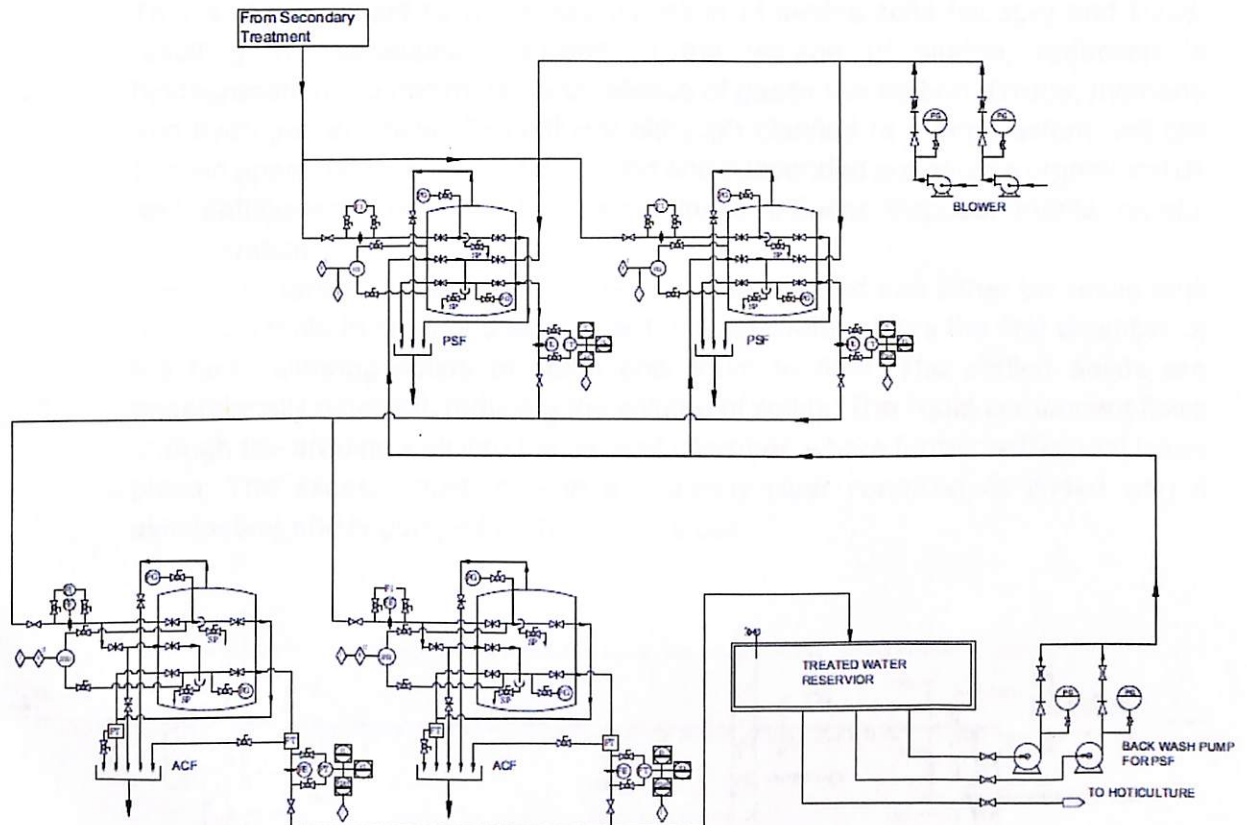


FIGURE: 3

B) Septic Tank and Soak Pits.

Septic Tank and Soak Pits are provided in the power plants areas that lack connection to main sewage pipes provided as these areas are far off from the main power plant network i.e. offsite plants.

i) Septic Tanks:-

Septic tanks is a combined sedimentation and digestion tank where sewage is held for one or two days. During this period, the suspended solid settles down at bottom. This is accompanied by anaerobic digestion of settles solid (sludge) and liquid, resulting in reasonable reduction in the volume of sludge, reduction in biodegradation organic matter and release of gases like carbon dioxide, methane and hydrogen sulphide. The effluent although clarified to a large extent, will still contain appreciable amount of dissolved and suspended putrescible organic solids and pathogens. Therefore the septic tanks effluent disposal merits careful consideration.

The septic tanks are normally rectangular in shape and can either be single tank or double tank. In case of double tank the wastewater enters the first chamber of the tank, allowing solids to settle and scum to float. The settled solids are anaerobically digested, reducing the volume of solids. The liquid component flows through the dividing wall into the second chamber, where further settlement takes place. The excess liquid, now in a relatively clear condition, is dosed with a disinfectant and is pumped for horticulture use.

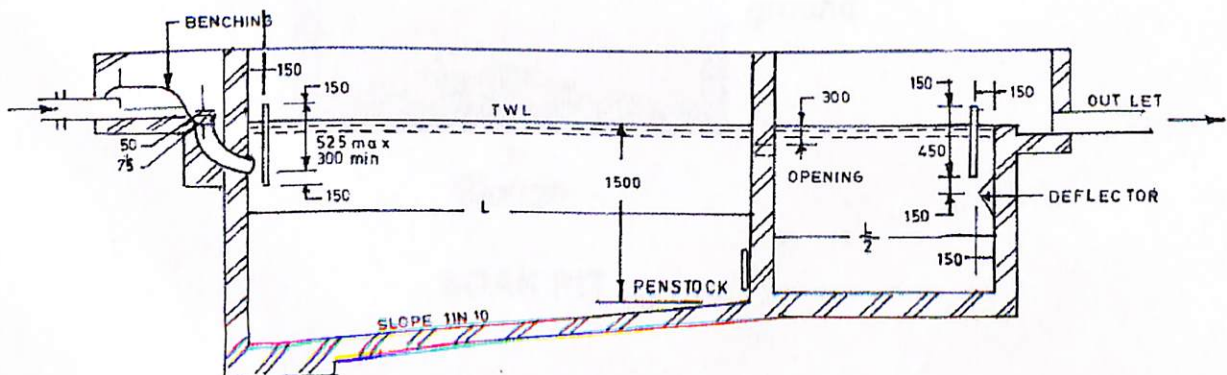


FIGURE: 4

ii) Soak Pits:-

Soak pits or seepage pits are cheap to construct and were extensively used. A Soak Pit is a covered, porous-walled chamber that allows water to slowly soak into the ground. Pre-settled effluent from septic tank is discharged to the underground chamber from where it infiltrates into the surrounding soil. The pits may be of any regular shape, circular or square being more common. The Soak Pit is filled with coarse rocks and gravel. The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the waste-water. As waste-water percolates through the soil from the soak pit, small particles are filtered out by the soil matrix and organics are digested by micro-organism.

Septic Tank and Soak Pit arrangement is banned in many of the Indian States due to high BOD and pathogens in the effluent which contaminate ground water table.

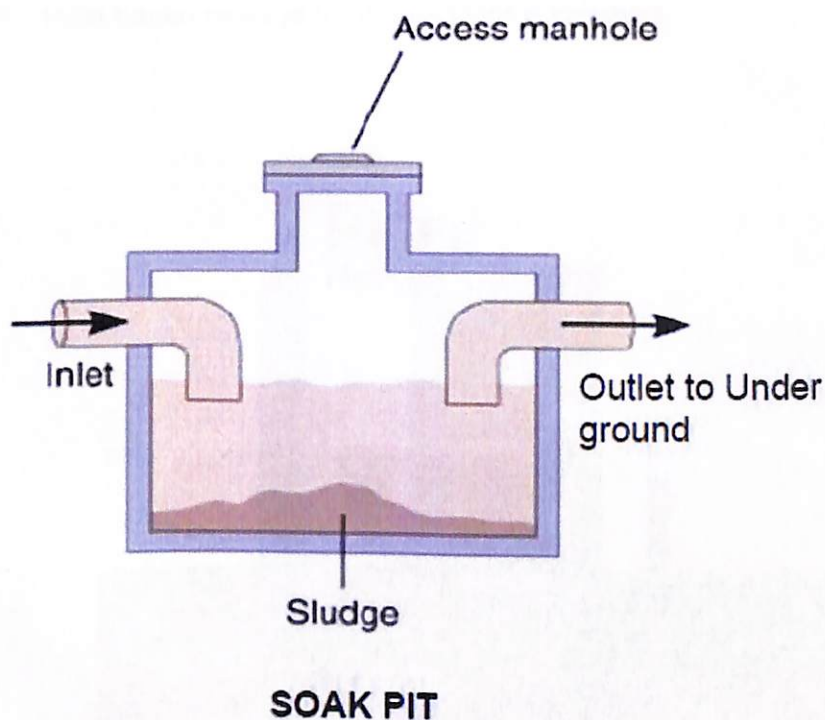


FIGURE: 5

4.0 NEW AND ALTERNATE TECHNOLOGY OF SEWAGE TREATMENT PLANT

There are many latest highly advanced technologies which could be used as an alternatives to conventional aerobic treatment mainly are:-

1. Activated Sludge Process.
2. Biological Filtration and Oxygenated Reactor (BIOFOR Technology).
3. Fluidized Aerated Bed.
4. Submerged Aeration Fixed Film Technology.
5. packaged sludge treatment plant
6. Bio-toilets.

5.0 TECHNOLOGY CONSIDERED FOR STUDY:- BIO-TOILETS

All the alternate technologies to conventional aerobic treatment as mentioned above, are very complex involve high operating and maintenance cost. As an alternative for the same Bio toilet based sewage treatment plant is selected.

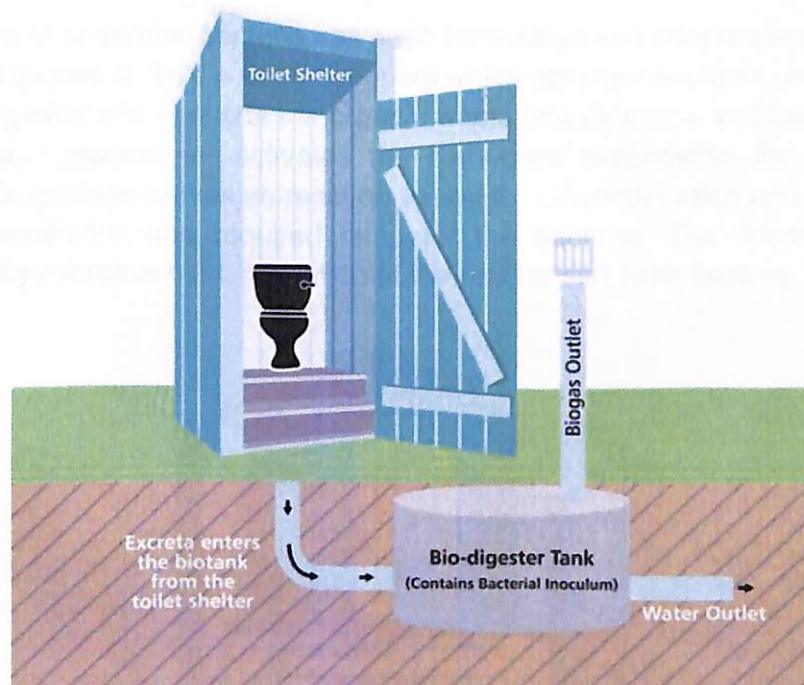


FIGURE : 6
Typical layout of Bio-Toilets

5.1 WHAT IS BIO-TOILET

Bio-Toilet is a complete waste management solution which reduces solid human waste to Bio-gas and pure water, with the help of an anaerobic bacterial inoculum. The residual water from Bio-Toilet is colorless, odorless, pathogen free and devoid of any solid particles, which can be used for horticulture or can be recycled back for use in flushing system.

The main constituents of a conventional Bio -Toilet are Pre-fabricated above the ground shelter and Bio Digester tank. Bio digester tank is a tank with the provision of inlet for human waste and out let for Bio gas and clean water. Temperature in the bio – digester is maintained between 5-30 degree C. A person can use the toilet which is connected to the bio-digester. Night soil degradation occurs through microbial reaction which converts it into bio gas. The gaseous effluent (bio-gas) is continuously let off to the atmosphere or can be used for various energy incentive activities like cooking water and room heating. Treated water can be used for horticulture or can be recycled back for use in flushing system.

5.2 WORKING OF BIO TOILETS

A consortium of anaerobic bacteria has been formulated and adopted to work at temp as low as -5 degree C. This is the component which acts as inoculums (seed material) to the bio digester and converts the organic waste into methane and carbon-dioxide. The anaerobic process in- activates the pathogens responsible for water borne diseases. Bio digester serves as reaction vessel for bio meth nation and provides the anaerobic conditions and required temp for the bacteria. The optimum temp is maintained by microbial heat, insulation of the reactor and solar heating.

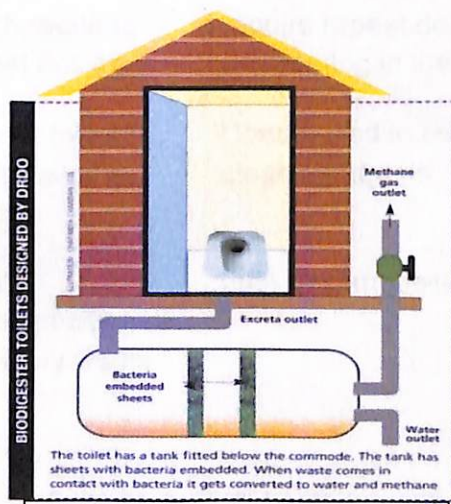


FIGURE: 7

6.0 COMPARISON OF NORMAL TOILETS WITH BIO TOILETS

TABLE : 1

FEATURES	NORMAL TOILET	BIO-TOILET
COMPOSITION	Toilet Structure & Septic Tank	Toilet Structure & Bio-Digester Tank
SPACE	3 X Space occupied by Bio-Toilet	1/3rd space occupied by the Septic Tank
MAINTENANCE	Quarterly	No maintenance cost for minimum 50 years
PUMPING INFRASTRUCTURE	Electricity required	No Electricity
WASTE DISCHARGE	Has odor, sludge properties & is hazardous to the environment	Odorless & colorless & hazard-free
BACTERIAL REQUIREMENT	Aerobic Bacteria which requires repeat dosing	Anaerobic Bacteria which does not require repeat dosing – is capable of procreating in the Bio-Digester Tank
TOLERANCE FOR CLEANING AGENTS	Cannot tolerate toilet cleaning agents	Conditioned to remain unaffected by cleaning agents
WASTE DECOMPOSITION	30% decomposition of excretory waste	90% decomposition of waste

7.0 COMPARISON OF BIO TOILETS WITH SEPTIC TANKS WITH BIO TOILETS

TABLE :2

Features	Septic Tanks	Bio Toilet
Composition	Tank	Biodigester tank
Technology	No Technology	Tank contains Bacterial Inoculum
End Products	Sludge & Nitrates	Water & Bio gas
Waste Empty	Quarterly	Not Required
Maintenance	Annual Repairs	No maintenance cost for minimum 50 years
Decomposition	30%	90%
Space	3X Bio-toilets	Average 1 M3

8.0 COMPARISON OF BIO TOILETS WITH SOAK PITS

TABLE :3

Features	Soak Pit	Bio Toilet
Composition	Pit dug in the ground with a gravel coated filtration mechanism.	Toilet structure & Bio-digester tank
Technology	Soak pit has no technology	Anaerobic Bacteria - waste decomposed into water & biogas
Waste discharge	Has odour, sludge & is hazardous to the environment	Odourless, colourless & hazard-free
Waste decomposition	Up to 10% maximum decomposition	90% decomposition of waste
Application	Households only	Households, community & Mobile applications
Bacterial requirement	Contains aerobic bacteria	Contains Anaerobic Bacteria
Tolerance for cleaning agents	Cannot tolerate toilet cleaning agents	Conditioned to remain unaffected by cleaning agents
Maintenance	Requires quarterly emptying	No maintenance cost for minimum 50 years
Space	Average 1 m ³	8 ft x 4ft Average size

9.0 BENEFITS

Usage of Bio Toilets has the following Benefits:

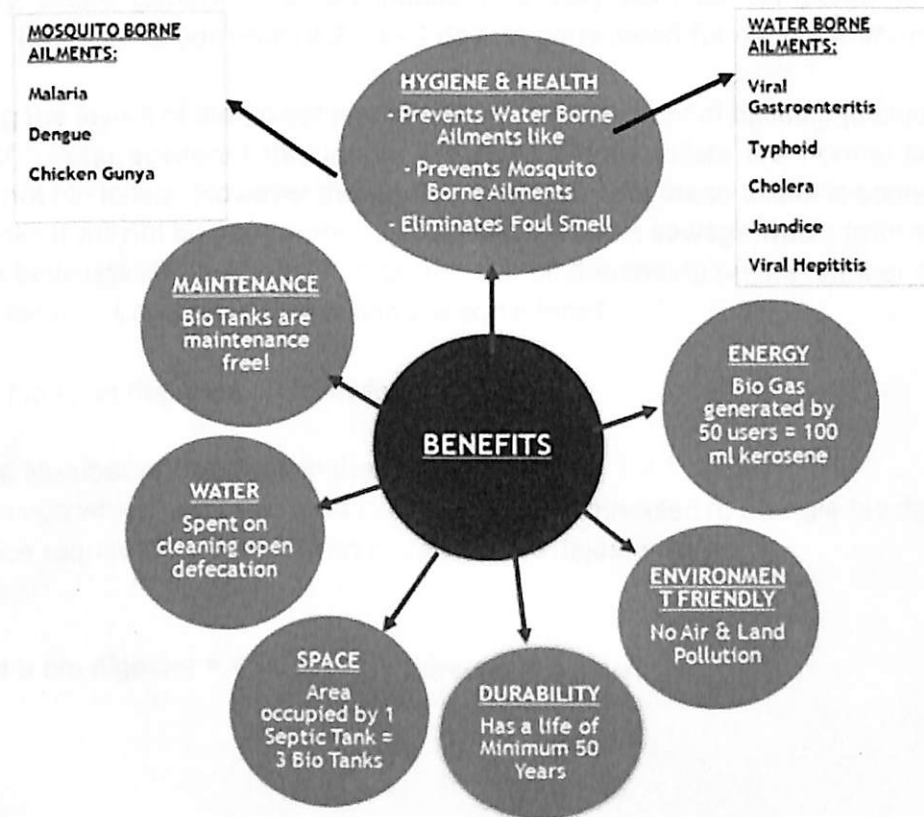


FIGURE: 8
Benefits of Bio-Toilets

10.0 CRITERIA FOR DESIGN OF THE BIO-TOILET IN A POWER PLANT.

Quantity of sewage waste generated per person per day (45 l per person per day) is considered based on CPHEEO (CENTRAL PUBLIC HEALTH AND ENVIRONMENTAL ENGINEERING ORGANIZATION) Manual.

As Sanitary waste generated in an industrial is very lean as compared to residential complexes, hence retention time of 2.5 to 3 days is considered for decomposition of waste.

Considering the layout of the power plant there will be n number of building (including various numbers of toilets) scattered throughout the plant. These toilets are normal conventional toilets and not bio toilets. However the waste generated from these toilets is connected to bio digester tanks It will not be geographically possible to collect sewage waste from all the toilets from all the buildings into a single bio digester. Hence depending on the number of buildings, layout and locations number of bio toilets are considered.

Number of bio toilet depends on following factors:

1. Total Number of Buildings in the Power Plant.
2. Buildings which can be formed in a cluster and connected to a single bio digester tank.
3. Space requirement wrt location of various bio digester tanks.

Capacity of a bio digester = $45 \text{ L} \times \text{No of persons} \times 3 \text{ days}$.

11.0 COST ECONOMICS:-

The following are the cost economics saving are involved in Bio-toilet as compared to conventional sewage treatment plant:-

A) Capital Cost:-

- Civil construction cost. Earlier Sewage was collected in individual lifting station and then transferred to a common sump in sewage treatment plant and then treated. However in this technology lifting stations work as bio digester tanks and hence a lot of civil work is saved,
- Reduction in Pumping and Piping Cost- Earlier Sewage was collected in individual lifting station and then transferred to a common sump in sewage treatment plant and then treated. However in this technology lifting stations work as bio digester tanks, hence no pumping and piping requirement is applicable
- A clean and green technology. Sewage treatment plant was always located away from the plant near the plant boundary due to sewage and foul smell which then increased the cabling cost, increase in local control panel etc, however Bio digesters can be placed at any location in the power plant, hence a lot of cost is saved.
- Erection is very simple hence almost erection cost is negligible

B) Direct operation and maintenance costs:-

- Reduction in chemical and consumable cost. Inoculum is to be added only once so a lot of cost saving is done on Chemicals and consumables.
- Fuel and Electricity cost.
- Maintenance and Repairs cost.
- Cost incurred due to skilled labour.

12.0 USAGE OF BIO-TOILETS IN POWER PLANTS

Bharat Heavy Electricals Limited (BHEL) is India's largest power plant equipment manufacturing company and 7th largest power equipment manufacturer in the world. BHEL was established in 1964 and over the period of time have developed the capability to produce a variety of electrical, electronic and mechanical equipment's for power sectors, transmission, transportation, oil and gas and other allied industries. The company is engaged in the design, engineering, manufacturing, construction, testing, commissioning and servicing of a wide range of products, systems and services for the core sectors of the economy, viz. Power, Transmission, Industry, Transportation, Renewable energy, Oil & Gas and Defence.

Waste Water Treatment in a power plant consists of Effluent Treatment and Sewage Treatment. Sewage Treatment Plant consists of collection of sewerage from various buildings of the power plant and transferring the same to a centralized sewage treatment system. After treatment of sewage, the treated water generated is disposed to nearest drain or used for horticulture as per customer's requirement. However various environmental norms formulated by agencies like MoEF (Ministry of Environment and Forests), CPCB (Central Pollution Control Board), SPCB (State Pollution Control board) have endured that the effluents are properly treated and reused thus achieving a zero discharge.

Existing common practice followed in the field of Sewage Treatment Plant for a power plant is conventional aerobic treatment system for the main power plant and Septic Tank and Soak Pit for Far off scattered areas in the power plant.

Septic tank and soak pit are problems in itself w.r.t contamination of ground water level, collection and disposal of sludge in a septic tank etc.

Pumping of sewage adds to auxiliary power which is again an emerging issue for the end user and has to reduce to the minimum level.

Considering the above problems catering to conventional sewage treatment plant and the stringent guidelines for disposal of treated sewage, many customers have approached BHEL for an eco-friendly alternate technology.

Taking care of the above requests from various customer a new methodology of Bio- Toilets has been worked out as an alternative to conventional sewage treatment plant which takes care of the additional auxiliary power and also sludge disposal.

This project work on bio toilet based sewage treatment plant thus, will not only help BHEL/End user to save additional cost incurred on pumps and piping but also the problems related to pipe routing, Also, this technology is environmental friendly with no sewage generation and hence will meet all environmental norms formulated by state and central pollution control boards.

13.0 CONCLUSION:

Conventional sewage treatment system has become cumbersome and costly. Moreover the stricter environmental norms make the system ineffective. To overcome the disadvantages faced in the conventional sewage treatment, new technologies have been developed. Bio-Toilets have proved to be an effective way of treatment of the sewage. The system not only is economical but also efficient and at the same time environmentally friendly.

Thermal power plants with wide distribution of working areas face the problem of sewage collection and transport to a central sewage treatment plant. Bio Toilets have successfully overcome this problem and has provided an efficient and eco-friendly alternative.

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Bharat Heavy Electricals Limited

Power Sector-Project Engineering Management
PPEI Building, Plot No. 25 Sector-16A, NOIDA - 201301



Ref: PE/A01/JP

Date: 26.08.15

LETTER OF ACCEPTANCE

To,
Academic Coordinator-CCE,
University of Petroleum & Energy Studies,
210, Okhla Industrial Area, Phase-III
Delhi-110020

To Whom It May Concern

Respected Sir/Madam,

With reference to the application by Sh. Sudeep, student of third year MBA (Power Management) SAP ID 500025513 of your college shall carry out work embodied in the project report entitled "Bio Toilets- A green clean alternative of Sewage Treatment Plant in Power Plants" under my supervision and guidance from 10/09/2015 to 20/10/2015.

Thank You.

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Sr. Manager, Mechanical Auxiliaries

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