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Review Article

Root-zone technology as energy efficient and cost effective for sewage water treatment

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Abstract

The process of design, construction and operation of sewage treatment plant (STP) requires multi disciplinary approach. Numerous conventional methods are available for design of sewage treatment plants. The process involved in these treatments is either aerobic, anaerobic or combination requiring number of mechanical and electrical items thereby requiring substantial energy. The ever growing need of energy makes the design, operation and maintenance of STP a challenging task. The conventional method of sewage treatment can be made efficient by advanced technologies and intelligent supervision. However, root zone technology developed by National Environmental Engineering Research Institute treats the sewage. It is found from the study carried out on nine STPs at various locations, it uses only 20% of the energy as compared to conventional sewage treatment plants.

Keywords: sewage treatment plant, root zone technology, energy-efficient and cost-effective.

Introduction

Conventional technologies of wastewater treatment are highly power intensive and are thus not desirable in the present era of climate change and energy conservation. These technologies are also capital intensive and usually lead to wastage of valuable resources like biomass and nutrients. Root zone technology is a novel technology for wastewater treatment with low cost and energy saving. Root Zone technology is the nature's answer to the modern industrialized world's water pollution problems [3]. Growth of wet land plants called reeds in specially designed beds provides eco-friendly

mode to use nature to "Protect Nature" as the net work of Rhizomes and naturally occurring bacteria associated with their root structure to help in breading down of organic solids present in the waste water [5]. This technology has been successfully used for treatment of sewage in many towns and villages of Germany and Egypt [4].

Root Zone Treatment System are planted filter-beds consisting of sand/gravel/soil. The Root Zone Treatment System uses a natural way to effectively treat domestic & industrial effluents. This Technology was developed in 1970's in Germany and is successfully running in different countries, mainly in Europe, India and America. The process incorporates the self-regulating dynamics of an artificial soil eco-system. RZTS are well known in temperate climates and are easy to operate on-site treatment facilities, which have less installation and low maintenance & operational costs [7].

What is it exactly root zone technology?

Root-zone technology is also know by various other names like Root-zone System or Bio-Filter or Reed Bed System or Constructed wetland system or Treatment wetland system or Phytotechnology or Phytoremediation system. "Phytoremediation is the name given to a set of technologies / methods based on various mechanisms associated with root-zone of different plants. This system leads to decontamination, destruction, containment of pollutants [6].

Sewage treatment plant

Primary water source is polluted to a great extent through discharge of harmful substances. It is estimated that every 1 m3 of contaminated water once discharged into water bodies will contaminate further 8 to 10 m3 of pure water. Out of the 31 diseases that are major cause of death in developed countries, as many as 21 are due to contaminated water. The above facts highlight the need to find improved water treatment to meet the problems of food security, water availability and use of water efficiently. It is beyond any doubt that energy will be the main concern of the nations in coming years. Identification and adoption of appropriate technology to overcome these pressures is therefore absolutely essential. The object of sewage treatment is to stabilize the organic matter present in sewage so as to produce an effluent liquid and sludge, which can be disposed-off into the environment without causing health hazard or nuisance [5].

The endeavor should be to adopt modern and cost-effective technologies and equipment to achieve value for money and maximum user satisfaction. The septic tanks which treat the sewage by pure anaerobic process can be considered as preliminary sewage treatment plant (STP). The requirement for better treatment of sewage coupled with development of technology lead a way forward towards aerobic process. This requires pumping and blower operation which is energy consuming. Thus conventional STP requires energy for achieving better results .The aerobic process requires oxygen to be provided to the bacteria [1].

Chong et al. 2010 discussed the recent developments in photo catalytic water treatment technology. The ability of this advanced oxidation technology has been widely demonstrated to remove persistent organic compounds and micro-organisms in water. Novak and Horvat et al. 2011 discussed the structured mathematical models which combined the use of oxygen electrode and biological waste water treatment to optimize the position of electrode in the bio-reactor for efficient transfer of oxygen. The overgrowing need of energy makes the design, operation and maintenance of STP a challenging task. Poch et al. 2000 deliberated on improvement of conventional wastewater treatment through an intelligent integrated supervisory system. Recently developed concept of treating the sewage by root zone technology provides aerobic and anaerobic treatment simultaneously in one tank. Yang et al. 2008 used phyto-remediation for treating contaminated site and concluded that it is

an efficient, economical, and environment friendly ecotechnology. Besides these advantages, phytoremediation has considerable potential for environmental restoration of contaminated sites. Pawaskar et al. 2012 has suggested modification in root zone technology that overcomes the limitation of huge area requirement for application of constructed wetland (CW). The modified CW can be effectively used within the nallah area to treat incoming waste water with techno-economical feasible option. Vymazal et al. 2008 discussed that horizontal sub-surface flow constructed wetlands. Zhang et al. 2009 carried out comparison between the cost of a conventional wastewater treatment processes and CW. It showed that the CW does not have any advantage in construction cost. However, it has advantage in operation and maintenance cost. The operation and maintenance cost of conventional plant was found to be Rs 16/m3 whereas CW was Rs 1/ m3. The main objective of this study was to identify energy-efficient design parameters for a conventional STP and comparison of construction, operation and maintenance cost of STP by phytorid technology.

Mechanism of treatment

1. Extraction of contaminants from soil or groundwater.
2. Degradation of contaminants by various biotic or abiotic processes.
3. Breakdown action carried out by microorganisms dwelling at the root zone degrade / breakdown pollutants.
4. Filtration process / biofilm formed at surface of pebble /gravel / coarse sand bed.
5. Processes like adsorption / absorption in soil strata or their combination.
6. Vertical and horizontal flow patterns & another possible mechanism for contaminant degradation is metabolism within the plant [5].

Applications

Best recommended for
1.) Septic tank outlet treatment.
2.) Treatment of polluted streams, nallas, rivulets and water-bodies (floating beds may be recommended).
3.) Bathroom water recycling.
4.) In combination with specific / simple pretreatments, it can be used as polishing treatment for any waste water. Eg – Brewery, (1) Sugar factories [4].

What is root zone treatment system (RZTS)?

The term 'Root Zone' encompasses the life interactions of various species of bacteria, the roots of reed plants, soil, sun and water. They are also known as constructed wetlands or sub-surface flow systems. In this system, these plants conduct oxygen through their stems into their root systems and create favorable conditions for the growth of bacteria. The wastewater flow through the root zone in a horizontal or vertical way where the organic pollutants are decomposed biochemically by the bacteria present in the rhizosphere of root plants. The filter media are selected carefully to provide favorable conditions for both plants & bacterial growth and to avoid clogging. Organic pollutants are removed drastically from wastewater and are reduced to their elemental forms [2].

General design criteria

The Root Zone Treatment installations are constructed according to the desired level of purification, the concentration of pollutants and hydraulic & organic loadings. The RZTS plants can be set-up as secondary or tertiary treatment for domestic and industrial wastewater treatment systems.

Table: 1

Sr.No	Type	Horizontal Bed (M^2/day)	Vertical Bed (M^2/day)
1.	Organic loading	10-30 gm BOD	20-40 gm BOD
2.	Hydraulic loading	40-100 litre	50-130 litre

For tropical/subtropical condition, however, the design criteria concerning to performance are still not available. It is expected that area requirement should be less in tropical climate because of enhanced microbial degradation process. On the other hand, there are some indications that in warm climates the filter media have to be selected differently to avoid clogging problems [5].

Root zone technology process

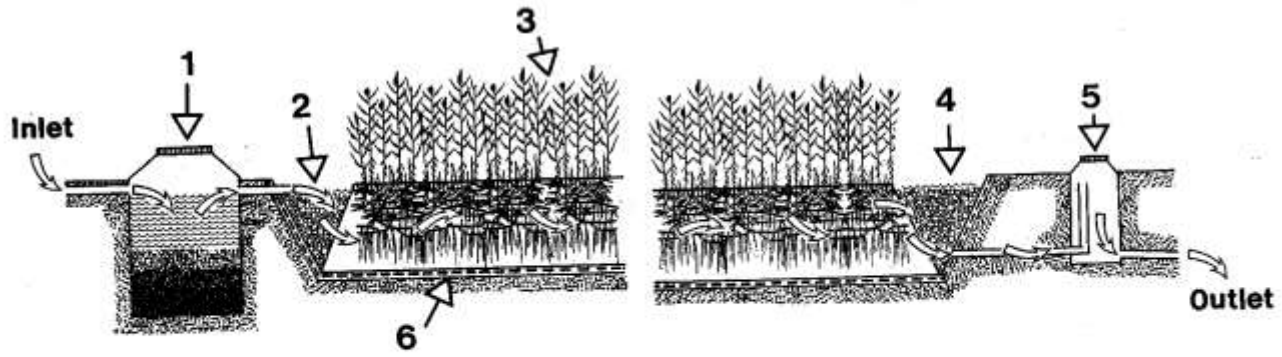

Fig. 1. Schematic representation of a root-zone treatment plant. 1: Sedimentation tank;, 2: Inlet channel; 3: Wetland plants; 4: Outlet channel; 5: Outlet weel with vertical tube for control of water level in outlet channel; 6: Watertight membrane.

The Root Zone process functions according to the laws of Nature, to effectively purify domestic and Industrial effluent. Root Zone encompasses the life interactions of various species of bacteria, the roots of the reed plants, Soil, Air, Sun and of course water [4]. Reed Plants have capacity to absorb oxygen from ambient air and creating numerous bacteria. Same bacteria oxidize and purifies in the waste

water. Since the process occurs underground inducing different types of chemical reactions, the process functions as a mirror of self regulating, purifying process found in nature. Three integrated components are essential in this system.

1). The reeds

2). The reed beds

3). Microbial organisms.

The output of clean nutrient rich water facilitates growth of flowers, vegetables etc. downstream. Alternatively this water can be pumped for use in field in upper reaches in a need and cost benefit basis [1].

Advantages

1). It achieves standards for tertiary treatment with low cost, such as no electricity, no chemicals for PH adjustment.

2). Low maintenance cost, since it involves no machinery and its maintenance.

3). It requires negligible attendance for operation and monitoring.

4). It has no sludge handling problem.

5). It enhances land scape and gives site a green look.

6). It provides natural habitat for birds and after few years gives an appearance of bird sanctuary.

7). Though it is a sewage treatment plant it doesn't have odors problem.

8). It becomes a green Zone and it does not have mosquito problem.

9). Above all it provides eco friendly solution to waste water treatment "Naturally" [4].

Conclusions

According to a latest third world Academy of Sciences report, of the 6 billion people on earth, more than one billion lack access to safe drinking water. About 2.5 billion do not have access to adequate sanitation sources. These shortcomings are responcible for more than 6 millions children's death every year. Today 31 countries reprsenting 2.8 billion people including China, India, Kenya, Ethiopia, Nigeria and Peru confont chronic water problems. Within ageneration the world population will be close to 8 billion people, the quality of water however will be the same. We have to find newer ways to save, treat and recycle the water [7].

Thus low cost, natural and energy saving technologies are a lot of attention these days due to their low installation cost, their ease of maintenance and less dependence on external inputs like power and chemicals, their potentially longer cycles and their ability to recover a variety of resources including treated effluent fir irrigation, organic humus for soil amendment and biogas etc. [6]. However, intensive research is needed in this area especially in developing countries to perfect the design factors and test the technologies at pilot and field level [4].

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