THE BIOTIC (CONTAMINATED WATER) TREATMENT SYSTEM

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Abstract

Sewage treatment in Australia is in general, rudimentary or overly complex, expensive and inefficient, wasteful and apathetic. Few if any currently operating sewage treatment plants in Australia may guarantee to consistently render wastewater totally safe.

The contemporary practice of municipalities is to concentrate wastewater at centralized sewage treatment plants and dispose of the polluted effluent directly or indirectly, into the nearest river or estuary. The problems of contamination by dangerous chemicals, toxic metals and pathogenic organisms are passed onto the next downstream user. These practices are progressively lowering soil fertility, seriously damaging our soil ecology, poisoning our rivers and coastal waters and pose significant health risks for all exposed fauna; including humans.

This paper examines a wastewater treatment system that has the potential to reuse household wastewater because of its significance as a very valuable resource, containing essential nutrients for plant growth. The Biotic Filter can safely utilize this resource and overcome the threat to human health posed by pathogenic organisms and prevent the degradation of the human and 'natural' environments by toxic pollutants. The Biotic Filter is a reliable on-site water treatment plant, capable of removing all pathogens from, as well as physically purifying the wastewater, being generated at suburban and rural house sites. These treatment plants have universal application, low establishment cost, durability, economic operation, low maintenance and are largely unaffected by variations in climate, environment and geographic location.

Keywords

Algae, antibiotic, biotic, humus, symbiosis, mycorrhiza, synergism

1. Overview of the Biotic Filter

The fully contained, waste (or contaminated) water treatment system described here, will consistently, economically, and reliably treat septic tank (or other secondary) effluent to any nominated level of purity including tertiary or advanced tertiary effluent. Reuse of the wastewater for garden watering would require it to comply to the tertiary standard.

The Biotic Water Treatment Plant (BWPS) is a new and innovative departure in simple, reliable, biological water purification (as was established in the course of the patent process by a world patent and contemporary practice search).

A modification of this system is capable of continuously, inexpensively and reliably generating potable water from the contaminated rivers, lagoons, creeks or wells currently supplying water to remote Australian communities.

A test model, currently treating all the domestic wastewater discharged from a single dwelling in Howard, Qld., after primary treatment in a septic tank, has consistently yielded a sparkling, crystal clear, odourless final water over an operating period of more than a year.

A BWPS is intermittently and automatically dosed by means float pumps fixed in the two dosing chambers accepting the effluent from septic tank and from the primary module of the filter respectively. The treated wastewater from a third chamber is automatically pumped to the selected reuse facility. Initial charging of the BWPS with wastewater may be by gravitational means or, if the system be retro-fitted, may require the use of a dosing pump. The operational process remains the same irrespective of the location or climatic variations.

The biotic water purification system is reminiscent in its action, of a (substantially modified) sub-surface, wastewater irrigation system, trickling filter or a wetlands scheme. It imitates and magnifies natural biological processes, in the reduction and oxidation of the dissolved and suspended solids (including nitrogen and phosphorus), the dissolved metals, the pathogenic bacteria, viruses, protozoa and parasitic ova and radio nuclides.

The surface of the system supports a lush vegetative cover. The very fertile environment created by the supporting media and nutrients from the waste water supports rapid vegetative growth, the cropping of which serves to remove nitrogen, phosphorus and biomass from the system. It is, in fact, a highly efficient hydroponic garden particularly suited for the rapid growth of shallow rooted plants such as cauliflower, cabbages and lettuces.

The system diverges from nature to the extent that the process is greatly accelerated by creating ideal conditions, in an artificially created environment, for the oxidation and decomposition of suspended and dissolved solids and the extraction of the wastewater nutrient

This decomposition is accomplished by imitating, nurturing and accentuating the natural synergistic relationship between the surface flora, insects, the clay, humus, soil bacteria, fungi, algae and actinomycetes that inhabit the biotic matrix and that effect the purification process. The biotic matrix furnishes an ideal habitat for an uncountable multitude of other contributing, competing and co-existing animal, vegetative, motile, predatory, parasitic and symbiotic microscopic and macroscopic organisms.

The structure of the BWPS consists typically of a matrix of 15 to 20 mm (approx.) balls of unglazed ceramic (plastic, glass or other) material forming a rigid, permeable and incompressible structure. The interstices of the structure are filled with a patented mixture of a simulated natural soil, evenly dispersed within the biotic matrix (of balls). This simulated soil contains no gravel, moderate proportions of silt and clay and a high proportion of natural humus and course sand. The biotic matrix (balls) takes up approximately 50% of the total volume of the structure, the remaining 50% being taken up by the simulated soil. This system has great stability with good, even and consistent porosity.

The dimensions of the system are variable according to the application, accepting only the depth that will be in general, 1200mm. Each half (module) of the domestic system illustrated has the dimensions of length and breadth 1500mm x 1500 mm and 1200mm deep.

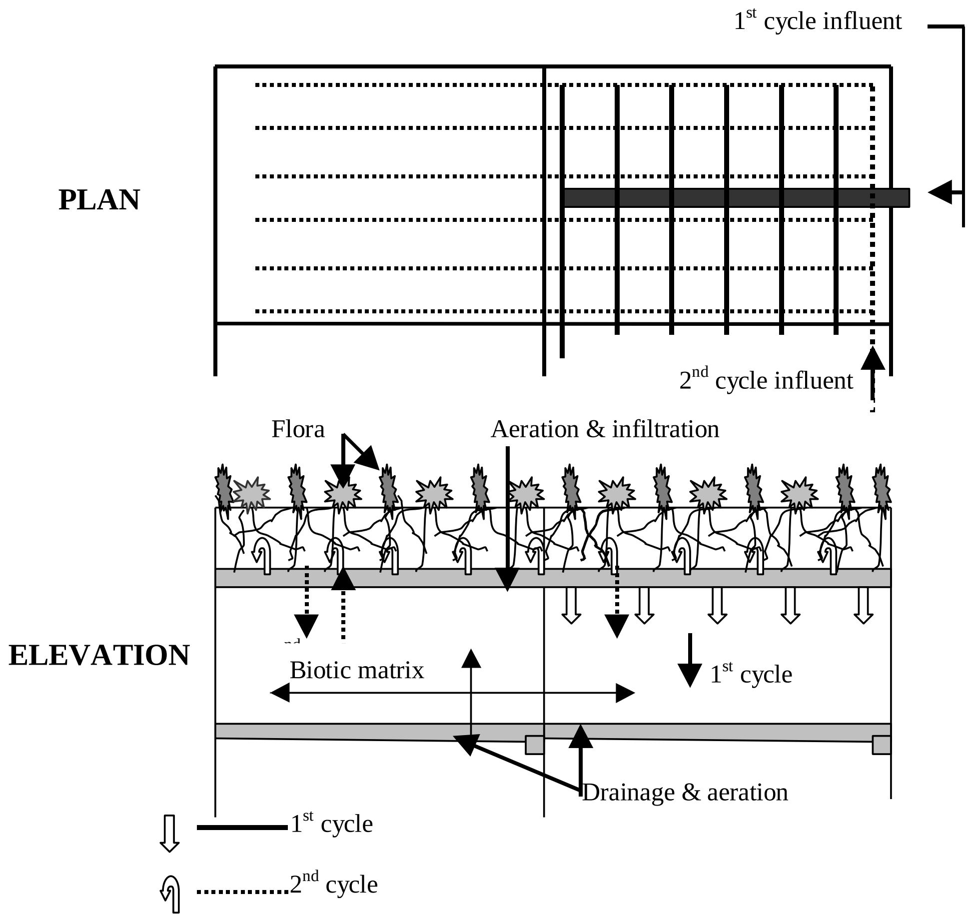
The sketch included below is of a design for a domestic version of the BWPS for purification septic tank effluent. The treated water is suitable for recycling to the toilet cistern, laundry system and for any other use other than human hygiene or drinking water.

The pumps required for the pilot system were:

- the initial dosing (Nova 300 float);
- the recycling pump (Davey D10 float); and
- the delivery pump (Davey D15 float).

The number of balls per cubic metre, approximately 125 000 and (dependent on the composition of the media), would have a total weight in the vicinity of 2000 kg.

2 System Structure



The system structure is alternately flooded with air and with water borne nutrients during the constant and frequent dosing cycles. This creates a benign environment for natural soil organisms that as a consequence, become enormously prolific and in the natural process of feeding on the nutrient matter, purify the polluted water.

The media at the infiltration level for the wastewater and at the bottom drainage level are dual purpose and are utilized to introduce air into the system.

Effectively, all pathogenic organisms including bacteria, viruses, protozoa and parasitic ova are removed or destroyed. Dissolved nitrates and phosphates are reduced to very low levels or removed. Dissolved metals are retained in the system and utilized as nutrients.

When high levels of water borne nutrients are introduced into this system, bacteria and actinomycetes proliferate and form a gelatinous mat of protoplasm that extends throughout the system. Bacteria and fungi form biofilms (zoogloeal slimes) directly onto these same surfaces. Other microscopic and macroscopic organisms that directly assimilate vegetative matter and animal wastes, proliferate to a population level limited only by the availability of nutrients and moisture. Parasitic, predatory and symbiotic soil organisms at the various trophic levels increase their population levels in concert.

This teeming ecology is observed fully developed in natural, well-watered (virgin) topsoil. Natural, rich topsoil (in Australia) typically has an effective depth of only about 200 to 300 mm. The porosity of the soil diminishes in concert with the depth and (in the lower horizons) as dense clay and silt become the predominant soil constituent. The limiting factor preventing the development of very deep topsoils is the lack of oxygen and anaerobic conditions caused by flooding of the soil with groundwater at an increased depth.

The BWPS has typically, by comparison, an effective depth of 1200 mm of a rich artificially formulated soil. This media furnishes an ideal environment for natural soil bacteria and other microscopic and macroscopic organisms and the balls forming the biotic matrix furnish a huge surface area (approx. 125 m^2/m^3), for the development of bacterial and fungal biofilms and a habitat for sessile organisms.

The vertical structure of the system does not vary regardless of the design capacity of the system. Consequently the design of any biotic wastewater treatment system (commercial or domestic) relates only to a simple function of design and scale expressed as surface area and relating primarily to the established constant percolation rate. For a typical domestic system of two modules the surface area would be (1.5 x 1.5 x 2) 4.5 m^2.

The wastewater treatment system has the following characteristics:

1. The plant operation is simple, reliable and consistent, the only mechanical components being simple dosing pumps;
2. The only monitoring of the system required relates to pump performance;
3. The very complex natural biological and chemical processes implicit in the system exist in a simple, stable, incompressible and durable structure;
4. Apart from the pumping system the lowest estimate of the life or term of viable performance of the system on the basis the known performance of natural systems (the sustainability) is likely to be in excess of 30 years.

This cyclic system incorporates in a single structure all the characteristics and significant ecological processes of those nutrient cycles found in nature. Some existing wastewater treatment systems, such as trickling filters and soil irrigation systems, also mimic nature but are less efficient in that the treatment is rudimentary or the water is not recovered for recycling.

The regular structure of ceramic or plastic balls forms a biological matrix both directly as a large surface area providing a benign environment for biofilm development, habitat and for the containment for the chemically and biologically active medium.

The natural biological and chemical medium filling interstices between the matrix balls provide a habitat for all the natural organisms to be found naturally in wetlands, rich topsoils, peat bogs and in unpolluted upland streams.

The system diverges from nature in that the depth of the rich simulated topsoil medium has been effectively increased from about 300 mm to 1200 mm. The rhythmic and alternate flooding with water and air simulates the wetting and drying cycles of a normal rain fed environment and the constant and elevated supply of nutrients provides non-limiting resources for vegetation.

The depth of the system and the cyclic introduction of nutrients (for the domestic system applied at a rate of about 25 L m^{-2}) from the surface and progressively down and through the system means that it is not unlikely that a vertical, hierarchical, Darwinian precedence will be established. This will relate to the biofilms (bacterial and fungal) and to all the other competing, parasitic, symbiotic and predatory organisms, and a synergic regime unusual in nature may be expected to develop.

This biological regime is likely to occur due to the progressive reduction of the concentration of the nutrients as they are cycled and advanced through the system in the carriage water. The synergistic effects will be reflected in the regional predominance of particular organisms responding to the variant nutrient conditions in the system.

The reduction of biomass within the system is effected by the grazing and predatory activities of macroscopic organisms that ultimately depart to the external natural environment. Thus the reduction of biomass will occur in the same manner that it does in the natural environment and should require no more than the regular cropping of the surface flora. There is consequently no predisposition to clogging or failure of the system in a typical household situation.

The system is expected to have the capacity to reduce pathogens, toxins and nutrients to insignificant levels. Being modular, it may be extended or modified to produce any nominated level of water purity (within the ultimate capability of the system). It may be easily fitted without any specialized design process, to treat the effluent from any domestic commercial or (municipal) primary wastewater treatment system, including existing septic tank systems. The area required for the installation of the system equals that defined by the external dimensions of the modules.

The implications of the successful deployment of this revolutionary, secondary wastewater treatment system are significant, for instance:

1. All urban dwellings could be detached from municipal sewerage systems, the greywater and blackwater discharged from the dwellings, treated and recycled through the laundry and toilet;
2. The excess treated water may be appropriately applied to water the landscaped areas surrounding the dwelling, (consequently avoiding drawing on the reticulated potable water supply for this purpose);
3. Water demand in residential urban areas could be reduced by approximately 60% because of the recycling referred to in (a);
4. Sewage treatment plants could have the sewage influent and effluent outflows reduced by approximately 60%;
5. The cost of procuring and storing water would be substantially reduced and the requirement for substantial new infrastructure set back for many years;
6. Consequently, the whole of the reduced effluent flow from the municipal sewage treatment plants could be economically treated to a near potable standard effectively reducing sewage effluent discharge to zero; and
7. Other ramifications are numerous including the redeployment of resources and lessening of environmental pollution.

3 Conclusion

Left to nature water percolates through a complex of soils, bogs, mosses, swamps, wetlands and forests. These natural features act as filters and reservoirs, holding and slowing the movement of water in the wet season and maintaining a flow in the dry season.

This moderating effect on the water flow sustains the ecosystem and is a vital component in the preservation of natural resources and in particular the water resource.

The activities of human kind have damaged and denuded these systems to the point that the water resource has been seriously diminished. A policy of conservation of the water supplies demands that wise use is made of this resource, hence the secondary use of water is important. There should be no wastewater.