



Studies on reusability of tertiary treated sewage in a university campus

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ABSTRACT

Water resources management is a predominant problem for future development in today's condition. Development of new technologies has extended the possibilities of wastewater reuse concept. Therefore, reuse of treated wastewater effluents has emerged as a renewable resource that increases in amount with the increase in water use. Inline with that, the wastewater treatment plants have come forth to implement tertiary filtration of secondary treated effluents to improve water quality for possible reuse in irrigation. In this present study, the characteristics of the tertiary treated effluent from granular activated carbon and pressure sand filtration are analyzed. The performances of the tertiary units are also monitored. The tertiary treated effluent is analyzed for applicability in agricultural purposes. The results revealed that treated sewage is applicable for gardening purposes but the removal of microbiological quality of the treated sewage was not at the satisfactory level. For removal of microbiological population, disinfection system such as UV/Ozonation can be installed for improving the quality of treated sewage.

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Introduction

Rapid urbanization and industrialization in the developing countries pose severe problems in collection; treatment and disposal of wastewater. Wastewater needs to be adequately treated prior to disposal or reuse in order to protect receiving waters from fecal contamination, deleterious oxygen depletion and ecological damage, and to produce microbiologically safe effluents for agricultural reuse. The systematic treatment of wastewater was followed in the late 1800s and early 1900s. The wastewater treatment systems are divided into primary, secondary, and advanced or tertiary treatment, making use of the physical forces and chemical and biological reactions.

The commonly employed sewage treatment systems include activated sludge process, trickling filters, rotating biological contactors, oxidation ditch, aerated lagoons, waste stabilization ponds, anaerobic lagoons and other anaerobic systems. The relative merits and demerits of these systems are well documented elsewhere¹.

Experience has shown that waste stabilization pond is one of the efficient, eco-friendly and economically viable options for wastewater treatment for tropical countries². Though the treated water from the waste stabilization pond can be discharged into river streams it can be further treated with tertiary treatment systems to reuse the treated water for agriculture. The various technologies in tertiary treatment are Membrane filtration, (which includes Microfiltration, Ultra filtration, Nanofiltration, Reverse osmosis and Electro dialysis), Adsorption, Gas stripping, Ion exchange, Advanced oxidation process and Distillation^{1,3-9}.

The different treatments can be applied according to the aim of the wastewater reclamation. Results showed that the most efficient conventional alternative consisting in settling + filtration + UV radiation and the treatment including ultra-filtration eliminated almost the 100% of the total coliforms¹⁰.

Comparative study of the economic costs and quality of effluents obtained from physicochemical-UV and macrofiltration ultrafiltration as municipal wastewater tertiary treatments. Both technologies present similar variable costs, while fixed costs of the membrane installation are double those of the physico-chemical-UV process, owing particularly to the high cost of the installation itself¹¹.

A process combination of powdered activated carbon (PAC) and nanofiltration (NF) called PAC-NF process is currently tested as a process for reclamation of sewage plant effluent on pilot scale¹². A study on an advanced treatment system, for the reclamation of secondary municipal effluents. The secondary effluents from a conventional activated sludge process were fed to an advanced wastewater treatment system, consisting of a moving-bed sand filter, a granular activated carbon adsorption bed and ozone disinfection. Sand filtration resulted in about 45% turbidity removal, while carbon adsorption enhanced mainly the removal of organic content, i.e. the total organic carbon removal exceeded 80%. The quality of treated effluents, obtained after ozonation by an ozone dosage of 26.7 mg/L, was found to comply with the respective United States Environmental Protection Agency (USEPA) proposed guidelines for urban reuse, food crop irrigation and recreational impoundments¹³.

Hence it is important to assess the treatment efficiency of the tertiary treatment units in the sewage treatment plant for reuse of the treated sewage. In this present study, the treated sewage from a Sewage treatment plant in a University campus (consisting of granular activated carbon and sand filtration as tertiary treatment units) was analyzed for applicability in agricultural purposes in order to overcome the water scarcity.

Materials and Methods

The existing sewage treatment plant in the university campus consists of the following components of unit processes such as Screen well, Grit well, Pump house, Oxidation ditch, Primary clarifier, Aeration tank, Secondary clarifier, Aerated lagoon, Waste stabilization pond, Pressure sand filter and Activated carbon filter. The flow diagram showing the treatment system is given in Figure 1.

Tertiary Treatment System

The salient details of the tertiary treatment system which comprises of pressure sand filter and granular activated carbon filter are given in Table 1 and Figure 2. To evaluate the performance of the system the secondary treated sewage from the waste stabilization pond and oxidation pond is fed to the Pressure sand filter and then to the Activated carbon filter.

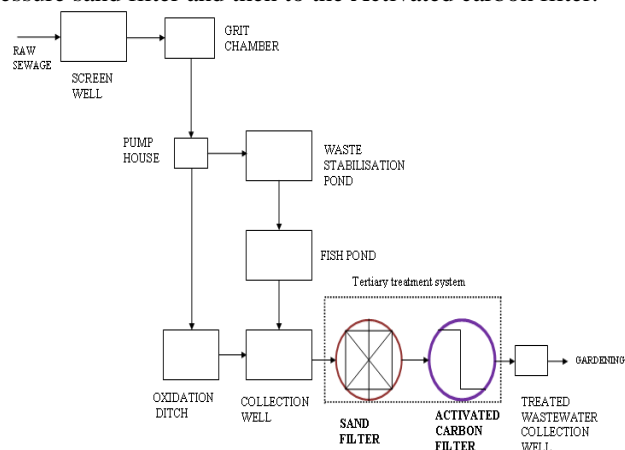


Fig 1 Sewage Treatment System at University Campus

And then the effluent from the activated carbon filter is to be characterized by using various experimental procedures and compared with the quality of the feed. This will be useful to know the performance of the unit.



Fig 2 Renovated Sand Filter and Activated Carbon Filter

Sample collection
Sewage samples were collected from the Inlet of Oxidation Ditch (sample A), Outlet of the Oxidation Ditch (sample B), Inlet of Waste Stabilisation Pond (sample C), Outlet of Waste Stabilisation Pond (sample D), Inlet of Tertiary Treatment System (sample E) and Outlet of Activated Carbon Filter (sample F). The wastewater was collected and stored in plastic cans, which will be kept in ice box. Then the wastewater was analyzed for various physical and chemical parameters within 24 hours of sample collection.

Experimental Parameters

The various experimental parameters considered for experimental characterization are pH, Phosphate, BOD, COD, TDS, Chloride, Sulphate and Total coliforms. The procedures followed were according to 'Standard Methods for the Water and Wastewater', American Public Health Association (APHA 1988)¹³.

Results and discussions

The results of the studies on various treatment units such as oxidation ditch, waste stabilization pond, pressure sand filter and Activated carbon filter in the Sewage treatment plant are presented and discussed below.

Secondary treatment units

The effluent characteristics of oxidation ditch and waste stabilization pond are presented in Table 2.

Tertiary Treatment Units

In the current study, the tertiary treatment system consists of Pressure sand filter and granular activated carbon filter. The tertiary filtration plays an important role in the stability of effluent quality so as to dampen the variations in the quality of secondary treated effluent.

Pressure sand filters have been used for wastewater treatment for over one hundred years. The sand media used in the filters and the microorganisms that colonize and reside in them are responsible for much of the wastewater treatment. Sand filter media quality is crucial to the operation and longevity of the filter.

Activated carbon filters are mainly used for the removal of offensive tastes and odors, colour, chlorine and potentially dangerous and carcinogenic organic compounds which are present in a wastewater system.

The outlet of the tertiary treatment system is compared with the Indian standards for sewage effluents discharge which is given in the Table 2.

Characteristics of the Tertiary Treatment System

The outlet characteristics of the wastewater from the tertiary treatment system are given in the Table 2.

Evaluation of pH

The average pH value of the treated effluent collected from the outlet of Tertiary treatment system was 7.32.

Evaluation of TDS

In the outlet of tertiary treatment system, the removal of total dissolved solids was found to be only 3%. This is owing to the fact that pressure sand filters and activated carbon have some limitations such as the inability to remove the dissolved metals like iron, lead, manganese and copper; some anions such as chlorides, nitrates and fluorides. Hydrogen sulphides are removed only in small amounts.

Similar results were obtained in the study conducted in the tertiary treatment of tannery effluent in a CETP removed around 4% of TDS¹⁴.

Evaluation of Chloride, Sulphate and Phosphate

The removal of chloride, sulphate and phosphate in the tertiary treatment system was found to be in residual amount. This minimum removal was due to the fact that pressure sand filter and activated carbon filter have very minimum affinity towards the removal of dissolved inorganic species¹. The results correlate well with a removal of TDS in the tertiary treatment system.

Evaluation of BOD

The efficiency of BOD removal in the tertiary treatment system was about 77%. This is due to the reason that majority of

BOD in the form of VSS could be removed by filtration process through pressure sand filtration and activated carbon filtration.

Moreover the filter medium is regularly backwashed thus; the microbial attachments or the biofilms are washed out and would not accumulate in the filter¹⁵. The overall removal of BOD by the tertiary treatment system, around 50% of BOD removal may be attributed to the filtration in the pressure sand filter. These plausible justifications are obtained¹⁶.

Evaluation of COD

The average removal efficiency of COD in the outlet of tertiary treatment system was about 71%. This is due to the fact that the pressure sand filter is filled with sand and water, which is allowed to pass through under pressure. The application of pressure over the sand facilitates the settlement of solids and organic matter in the sand. But, the complete removal of organic compounds in the form of odour and volatile organic solids is not possible by pressure sand filtration¹⁷. Hence, the effluent is passed through an adsorbing medium like activated carbon filter.

Granular Activated Carbon filter has the ability to reduce the level of organic matter as well as levels of specific trace organics. Majority of the COD removal must have been carried out in activated carbon filtration, since GAC has the greater affinity to adsorb aromatic solvent, chlorinated aromatics, polynuclear aromatics, pesticides, herbicides, chlorinated non-aromatics and high molecular weight hydrocarbons. Hence, considerable amount of organic matter is removed from effluent, when it is passed through the activated carbon filter.

But the complete removal of organic compounds is not possible even with the activated carbon filtration since, it has a lower adsorption affinity towards low molecular weight and polar organic compounds such as alkanes, aldehydes and amines with lesser carbon chain¹⁸.

Evaluation of Microbiological Quality

The removal efficiency of the microorganisms in the tertiary treatment system was about 20%. This removal was due to the filtration and adsorption of microbial population in the form of MLSS to some extent. But, the minimum removal of the microbial population is due to the reason that pressure sand filters and activated carbon filters are not effective against the bacteria¹⁹.

Conclusion

The total dissolved solids which are inorganic in nature are not removed by activated carbon filter but it can be removed by the pressure sand filter with two stage filtration. The tertiary treatment system consists of single stage pressure sand filter and thus the removal of total dissolved solids is not much more than the two stage filtration. The chloride, sulphate and phosphate are dissolved inorganic matter which cannot be removed by adsorption process. But the dissolved organic matter can be removed by Activated carbon filter.

The average BOD reduction in the tertiary treatment system was 77%. The average removal efficiency of COD in the tertiary treatment system was 71%. The removal efficiency of the microorganisms in the tertiary treatment system was about 20% this removal may be due to the filtration and adsorption of microbial population in the form of MLSS to some extent.

The results showed that the tertiary treated effluent values are below the Indian standard values for effluent discharge onland for irrigation. Hence, the tertiary treated effluent can be used for the gardening purposes. But, the removal of microbiological quality of the treated sewage was not at the satisfactory level. For removal of microbiological population,

disinfection system such as UV/Ozonation can be installed for improving the quality of treated sewage.

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Table 1 Salient Details of Tertiary Treatment System

Design details	Pressure sand filter	Activated carbon filter
Diameter	1.2 m	1.2 m
Height of shell	1.8 m	1.8 m
Capacity	150 m ³ /day	150 m ³ /day
Thickness of the filter media	800 mm	800 mm
Feed pressure	3 kg/cm ²	3 kg/cm ²
Backwashing feed pressure	4 kg/cm ²	4 kg/cm ²
Backwashing time	about 10mins for every 8hrs of operation	about 10mins for every 8hrs of operation

Table 2 The Characteristics of Raw Sewage, Secondary and Tertiary Treated Effluents

Parameters	Raw Sewage	Secondary Treated Effluents		Tertiary Treated Effluents	Indian Effluent Discharge Standard for On land Irrigation
		Oxidation Ditch	Waste Stabilization Pond		
pH	6.87	7.44	8.14	7.32	5.5-9
TDS (mg/L)	933	847	649	746	2100 mg/L
Chloride(mg/L)	167	164	164	150	600 mg/L
Sulphate (mg/L)	28	32	23	27.1	1000 mg/L
Phosphate(mg/L)	7.23	5.3	2.48	2.84	-
BOD(mg/L)	239	85	108	24	100 mg/L
COD(mg/L)	487	194	238	61	-
Total coliforms(MPN NO./100ml)	2.48x10 ⁷	8.8x10 ⁶	1.0x10 ⁷	7.3x10 ⁶	-