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A REVIEW ON REDUCTION OF PHOSPHATE FROM INDUSTRIAL CUM MUNICIPAL WASTEWATER USING MBBR TECHNOLOGY

Shadan Mohammad Sheikh[1], Dr. Sarita Sharma[2], Dr. Ashok Sharma[3], Dr. Sanjay Verma[4]

[1]*Mtech Scholar, Department of Chemical Engg, Ujjain Engineering College, Ujjain, (M.P.), India*
[2,3]*Professor, Department of Chemical Engg, Ujjain Engineering College, Ujjain, (M.P.), India*
[4]*Associate Professor, Department of Chemical Engg, Ujjain Engineering College, Ujjain, (M.P.), India*

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Abstract - *The removal of phosphorus (P) from domestic wastewater is primarily to reduce the potential for eutrophication in receiving waters, and is mandated and common in many countries. However, most P-removal technologies have been developed for use at larger wastewater treatment plants that have economies-of-scale, rigorous monitoring, and in-house operating expertise. Smaller treatment plants often do not have these luxuries, which is problematic because there is concern that P releases from small treatment systems may have greater environmental impact than previously believed. Here P-removal technologies are reviewed with the goal of determining which treatment options are amenable to small-scale applications. Significant progress has been made in developing some technologies for small-scale application, namely sorptive media. However, as this review shows, there is a shortage of treatment technologies for P-removal at smaller scales, particularly sustainable and reliable options that demand minimal operating and maintenance expertise. In view of emerging regulatory pressure, investment should be made in developing new or adapting existing P-removal technologies, specifically for implementation at small-scale treatment works.*

Key Words: **Municipal Wastewater, MBBR, Phosphorous, Physico - Chemical Processes, Wastewater Treatment Plants.**

1. Introduction

Phosphorus (P) releases due to anthropogenic activity promote eutrophication in aquatic ecosystems. For example in the India, the main sources of P entering rivers are sewage effluent and agricultural run-off with up to 70% being attributed to sewage discharges. This reality has resulted in tightening P discharge standards and increased pressure on the water industry to reduce P loads entering rivers, particularly to ecologically sensitive locations. As such, targeted P-removal has become increasingly common in large, urban wastewater treatment plants (WWTPs). However, sensitive watercourses also can be in more remote locations, receiving P discharges from smaller WWTPs. Further, wastewater from smaller communities is often treated less rigorously and the potential negative impacts of P release from small treatment works may be underestimated. The removal of P from wastewater can be performed using physico-chemical methods, biological treatment, and/or combinations of both, and many large-scale techniques are well established. However, translating such technologies to effective use at smaller scales has rarely been done and, as such, there is little information regarding the implementation and-or success of such systems. Small-scale treatment plants are different in that they may be less accessible than larger urban facilities; influent flows tend to be much more variable and subject to wider seasonal fluctuations; they are less rigorously managed and monitored; and wastewater composition often differs from urban sources. However, recovering P from WWTP effluent has high value, especially with growing P limitation on global scales. Here we examine currently available and also emerging P-removal processes for possible application at smaller scales. The review first describes different treatment technologies used at larger scales and associated mechanisms of P removal. The paper then considers which mechanisms might be exploited to deliver reliable P removal in smaller systems, including Enhanced Biological P removal (EBPR), algal based processes and passive, physico-chemical mechanisms, analyzing their pros, cons and their underpinning science. Finally, recommendations are made relative to directions for new work, especially research and development needed to create sustainable P removal in smaller systems in the future.

2. Various methods available for phosphate removal from waste water

Table-1: Different types of methods for phosphorus removal

Sr. No.	Category	Methods
1.	Physical	Filtration for particulate phosphorus
		Membrane technologies
2.	Chemical	Precipitation
		Other (mainly physical-chemical adsorption)
3.	Biological	Assimilation
		Moving Bed Biological Reactor (MBBR)

2.1 Physical Treatment

2.1.1 Filtration for particulate P

Assuming that 2-3% of organic solids is P, and then an effluent total suspended solids (TSS) of 20 mg/L represents 0.4-0.6 mg/L of effluent P. In plants with EBPR the P content is even higher. Thus sand filtration or other method of TSS removal (e.g., membrane, chemical precipitation) is likely necessary for plants with low effluent TP permits.

2.1.2 Membrane technologies

Membrane technologies have been of growing interest for wastewater treatment in general, and most recently, for P removal in particular. Membrane bioreactors (MBRs, which incorporate membrane technology in a suspended growth secondary treatment process), tertiary membrane filtration (after secondary treatment), and reverse osmosis (RO) systems have all been used in full-scale plants with good results. Reardon (2006) reported on several plants achi <0.1 mg/L TP in their effluent, and suggested the current reliable limits of technology are 0.04 mg/L for MBRs and tertiary membrane filtration, and 0.008 mg/L for RO.

2.2 Chemical Treatment

2.2.1 Precipitation

Chemical precipitation has long been used for P removal. The chemicals most often employed are compounds of calcium, aluminum, and iron). Chemical addition points include prior to primary settling, during secondary treatment, or as part of a tertiary treatment process. Song et al. (2002), using thermodynamics, modeled the effects of P and Ca concentration, pH, temperature, and ionic strength on theoretical removal. Researchers (e.g., Hermanowicz, 2006) generally agree, however, that the process is more complex than predicted by laboratory pure chemical experiments, and that formation of and sorption to carbonates or hydroxides are important factors. In fact, full-scale systems may perform better than the 0.05 mg/L limit predicted.

A major concern with chemical precipitation for P removal continues to be the additional sludge that is produced. This can be dramatic, especially if the method selected is lime application during primary treatment. Use of alum after secondary treatment can be predicted to produce much less sludge, but the increase could still be problematic.

2.2.2 Others

The precipitation methods described above rely in part on sorption to achieve the low concentrations observed. Möller (2006) reported on an iron reactive filtration system achieving <0.01 mg/L TP at a 1.2 MGD (average flow) plant. Woodard (2006) described a magnetically enhanced coagulation process that may achieve <0.03 mg/L TP based on long term pilot tests.

Gas concrete (produced from mixtures of silica, sand, cement, lime, water, and aluminum cake) waste was used to remove phosphate from pure aqueous solutions. High phosphate removal (> 95% in 10 min, batch system) was obtained from a 33 mg/L P solution, but direct applicability to wastewater treatment (lower concentrations, possible interferences) was not investigated. The gas concrete's removal efficiency can be regenerated at low pH, with the resulting concentrated phosphate solution potentially a source of recycled phosphate. Similarly, iron oxide tailings were found to be effective for phosphorus removal from both pure solutions and liquid hog manure.

2.3 Biological Treatment

2.3.1 Assimilation

Phosphorus removal from wastewater has long been achieved through biological assimilation – incorporation of the P as an essential element in biomass, particularly through growth of photosynthetic organisms (plants, algae, and some bacteria, such as cyanobacteria). Traditionally, this was achieved through treatment ponds containing planktonic or attached algae, rooted plants, or even floating plants (e.g., water hyacinths, duckweed). Land application of effluent during the growing season has also been used, and constructed wetlands are now an established practice as well. In all of these cases, however, it is necessary to remove the net biomass growth in order to prevent eventual decay of the biomass and re-release of the P.

2.3.2 Moving Bed Biological Reactor (MBBR)

The MBBR was developed in Norway at the Norwegian University of Science and Technology in co-operation with a Norwegian company Kaldnes Miljøteknologi (now Anox Kaldnes AS). The first MBBR was installed in 1989. Although it is a relatively new technology to the United States (first introduced in 1995), there are now over 400 installations worldwide in both the municipal and industrial sectors with over 36 in North America.

Two technologies are commonly used for biological treatment of sewage: activated sludge and trickling filters. A moving bed biological reactor (MBBR) is a compilation of these two technologies. The biomass in the MBBR exists in two forms: suspended flocks and a biofilm attached to carriers. It can be operated at high organic loads and it is less sensitive to hydraulic overloading.

The Moving Bed Biofilm Reactor (MBBR) is a highly effective biological treatment process that was developed on the basis of conventional activated sludge process and bio-filter process. It is a completely mixed and continuously operated Biofilm reactor, where the biomass is grown on small carrier elements that have a little lighter density than water and are kept in movement along with a water stream inside the reactor. The movement inside a reactor can be caused by aeration in an aerobic reactor and by a mechanical stirrer in an anaerobic or anoxic reactor.

Researchers have proven that MBBR possesses have many excellent traits such as high biomass, high COD loading, strong tolerance to loading impact, relatively smaller reactor and no sludge bulking problem. There are presently more than 400 large-scale wastewater treatment plants based on this process in operation in 22 different countries all over the world. During the past decade it has been successfully used for the treatment of many industrial effluents including pulp and paper industry waste, poultry processing wastewater, cheese factory wastes, refinery and slaughter house waste, phenolic wastewater, dairy wastewater and municipal wastewater. Recently, Moving Bed Biofilm Reactor (MBBR) has brought increasing research interest in practice for removal of biodegradable organic matter and its application has undergone various degrees of modification and development. Moreover, as the carrier using in the MBBR is playing a crucial role in system performance, choosing the most efficient carrier could enhance the MBBR performance. Hence, scientists have been looking for an appropriate carrier which is not costly and has a suitable surface for microbial growth. The main aim of this study is to evaluate a specific MBBR with polyethylene media as Biofilm support carrier in terms of OMs removal along with nutrient removal and microbial growth and activity.

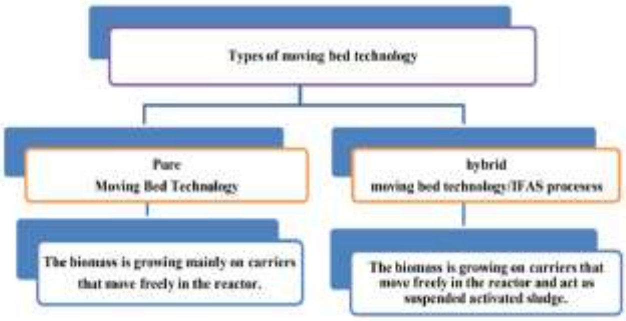

Fig -1: Types of Moving Bed Technology

Advantage of Moving Bed Biofilm Processes

The MBBR is a complete mix, continuous flow through process which combines the advantage of fixed film and suspended growth processes, this advantage include

1. Compact units with small size.
2. Increased treatment capacity.
3. Complete solids removal.
4. Improved settling characteristics.
5. Operation at higher suspended biomass
6. Concentrations resulting in long sludge retention times.
7. Enhanced process stability.
8. Low head loss.
9. No filter channelling.
10. No need of periodic backwashing.
11. Reduced sludge production and no problems with
12. Sludge bulking.

3. Experimental Set-up of MBBR

The Moving Bed Biofilm Reactor (MBBR) technology is an attached growth biological treatment process based on a continuously operating, non-clogging biofilm reactor with low head loss, a high specific Biofilm surface area, and no requirement for backwashing. MBBR is often designed as aerobic system. Samples will be collected from low income and high income society and its parameters will be evaluated prior to treatment. The proposed experimental set-up for Moving Bed Biofilm Reactor can be made as shown in Fig. 2 The Moving Bed Bioreactor (MBBR) setup proposed for this study will be made up of glass containing three compartments. The inlet arrangement for influent pre-treated raw domestic waste water will be given at the top of tank. The Outlet will be provided at lower level than inlet.

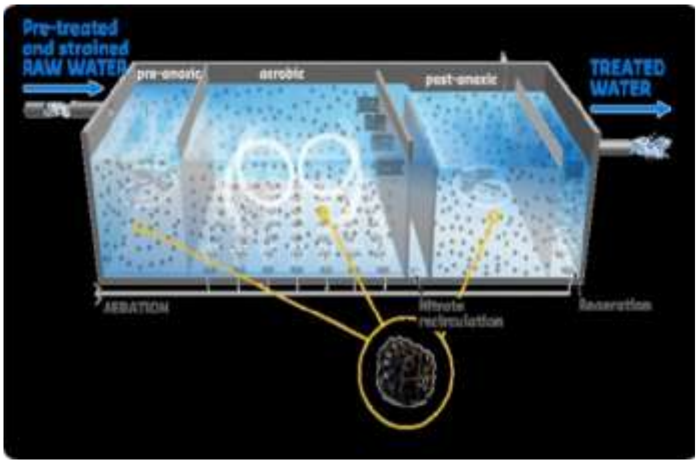

Fig: 2 Experimental Set-up of MBBR

The Moving Bed Bioreactor (MBBR) process uses floating plastic carriers (media) within the aeration tank to increase the amount of microorganisms available to treat the wastewater compared to conventional secondary treatment. The microorganisms consume organic material. The media provides increased surface area for the biological microorganisms to attach to and grow in the aeration tanks. The increased surface area reduces the footprint of the tanks required to treat the wastewater. The media will be continuously agitated by bubbles from the aeration system that adds oxygen at the bottom of the first compartment of the aeration tank. The microorganisms consume organic material. The middle compartment will contain a channel of stones. The bottom portion of channel will contain large sized stones and upper channel will be of small sized stones. The waste water will be filtered through stone bed to some extent. After filtering, it will enter to last compartment through the openings provided in the setup. In last portion of tank where the bio carriers will be filled, turbulence will be provided to waste water with the help of rotors. After treatment, final treated effluent will be taken outside through outlet.

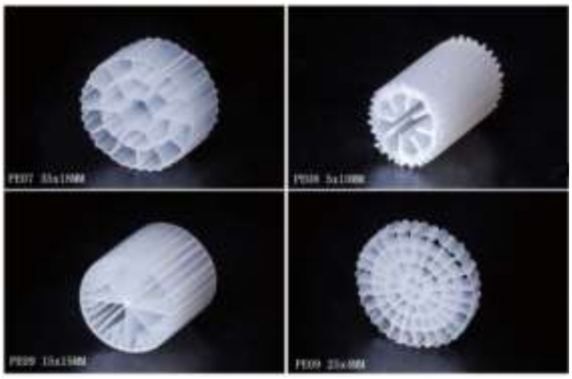

Fig: 3 Bio Carriers

Table-2: Characteristics of the bio media

Material	Polypropylene, plastic, ceramic, porous
Shape	Corrugated cylinder, chips, hollow, curved
Density	0.95 g cm−3
Dimensions	10×15 mm
Specific surface	260 m2 m −3

4. Operating Principle

The MBBR is a complete mix, continuous flow through process which is based on the biofilms principle that combines the benefits of both the activated sludge process and conventional fixed film systems without their disadvantages. The basic principal of the moving bed process is the growth of the biomass on plastic supports that move in the biological reactor via agitation generated by aeration systems (aerobic reactors) or by mechanical systems (in anoxic or anaerobic reactors). The moving bed processes come from the current trend in wastewater treatment, from the use of systems that offer an increased specific surface in the reactor for the growth of the biomass, achieving significant reductions in the biological reactor volume. Reactor can be operated at very high load and the process is insensitive to load variations and other disturbances.

5. Conclusion

Today the need for clean water is rapidly increasing. So MBBR is technology becoming increasingly popular and widely used in the world to treating different kinds of effluents under different conditions because the idea of the MBBR is to combine the two different processes (attached and suspended biomass). This study may be helpful to check possibility that the moving bed biofilm process can used as an ideal and efficient option for the total nutrient removal from municipal wastewater. The mode of change of aeration provided during the experimental work may affect the efficiency of waste water treatment to good extent. The Moving Bed technology may help to check the feasibility of waste water treatment by using both attached growth system and suspended growth system. This technology may be conducted to get low concentration of solids leaving the biological reactors, the absence of filamentous bulking and good settling characteristics of the sludge. The change in the type of media carriers during the experimental work may help to get the expected results in a very beneficial manner.

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