IOP Conf. Series: Earth and Environmental Science **32** (2016) 012005 doi:10.1088/1755-1315/32/1/012005

Application of Moving Bed Biofilm Reactor (MBBR) and Integrated Fixed Activated Sludge (IFAS) for Biological River Water Purification System: A Short Review

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Abstract. This review paper present the MBBR and IFAS technology for urban river water purification including both conventional methods and new emerging technologies. The aim of this paper is to present the MBBR and IFAS technology as an alternative and successful method for treating different kinds of effluents under different condition. There are still current treatment technologies being researched and the outcomes maybe available in a while. The review also includes many relevant researches carried out at the laboratory and pilot scales. This review covers the important processes on MBBR and IFAS basic treatment process, affecting of carrier type and influent types. However, the research concluded so far are compiled herein and reported for the first time to acquire a better perspective and insight on the subject with a view of meeting the news approach. The research concluded so far are compiled herein and reported for the first time to acquire a better perspective and insight on the subject with a view of meeting the news approach. To this end, the most feasible technology could be the combination of advanced biological process (bioreactor systems) including MBBR and IFAS system.

1. Introduction

Several methods can be used to purify the polluted river. Through implementation of proper analysis and environmental control, polluted river can be treated biologically. Among the selected methods of biological processes are using Moving Bed Biofilm Reactor (MBBR) and Integrated Fixed-Film Activated Sludge (IFAS). This is considered as attached growth secondary biological treatment in the water treatment process. Polluted river can be treated biologically, provided with proper analysis and environmental control. However, it is essential to understand the characteristic of each biological process to ensure the proper environment is produced and controlled effectively.[1]

MBBR process uses biological carrier as a media with a density close to water so that it can be kept in suspension with minimum mixing energy provided by aeration or mechanical mixing [2]. Biological carrier are manufactured in various shapes and are sufficiently large in specific surface area so that suspended support media can be retained in the reactor by screen or wire wedges.

This type of treatment process will be adapted for river purification as it increases biomass or biofilm concentration and treatment ability [3]. According to Briones & Raskin (2003), biofilm is defined as a microbial engineered community system which may comprise any type of microorganism including algae, fungi, bacteria, archaea and protozoa/ metazoan [4]. These multiverse microorganisms require the presence of a surface to adhere to and grow on, and biological carrier in MBBR and IFAS system will support as a media for them to grow.

Biofilm is one of the microbial attached growth processes in water/ wastewater treatment process. Meanwhile, another concept is suspended culture process. The most common suspended growth process used for municipal wastewater treatment is the conventional activated sludge (CAS) process. . Overall performance proves that MBBR has better rate of constituent removal efficiency compared to CAS in the laboratory basis study[5].

2. Moving Bed Biofilm Reactor (MBBR)

In the past, conventional activated sludge is widely used as biological treatment due to cost-friendly factor. Nowadays, a lot of modifications and upgrading works have been made to meet strict rules and regulations requirement for discharging treated wastewater into the natural water bodies Compact wastewater treatment plants that produce an effluent of high standard in the presence of smaller footprint and minimize waste is increasingly become worldwide concern particularly in the densely populated areas where limited space is available for the treatment plants.

Biological processes particularly MBBR and IFAS is one of the biological treatment processes in wastewater treatment which offer compact treatment plant design to overcome the drawbacks of CAS process and produce higher quality effluent even in smaller foot print.

2.1. MBBR Configurations

MBBR was developed by Kaldnes Miljøteknologi in cooperation with SINTEF, a Norwegian research organization and this system was firstly installed in 1990 [1]. In the MBBR process, small plastic carrier elements support the growth of biofilm in a continuously mixed reactor [6].

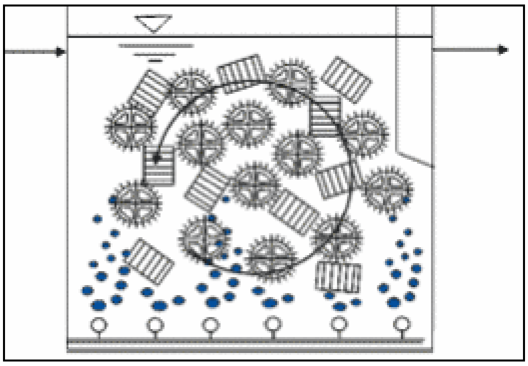


Figure 1. Aerobic MBBR reactor system[1].

MBBR systems are mainly based on the aeration rate and reactors filled with the specially designed biological carriers to provide a surface to colonize by bacteria. When the suspended porous biofilm carriers are continuously mixed in operated aeration tank as illustrated in Figure 1, active biomass will grows into biofilm on the surface of these carriers which having a density slightly less than the water [7]. MBBR system is the efficient method to retain slow growing microorganisms such as nitrifiers in the form of biofilm.

Field study had been conducted by Zimmerman (2005) prove that MBBR process is very flexible and can be retrofit into almost any size or shape of tank [8]. In general, the reactors are straight forward to install and maintain, requiring only a tank of adequate size and a bank of reactors

[9]. Ideally, the reactor is totally mixed with no dead space. The MBBR can be used to upgrade overloaded activated sludge, trickling filter, or other processes. A MBBR operates continuously and it is not affected by problem of clogging that may require backwashing or maintenance works. As compared to the fixed film system, the moving bed biofilm systems have much higher specific surface area for the biofilm [10].

2.2. Current Development of MBBR

The Wang (2006) carried out a laboratory scale test using biofilm carriers and a filling ratio of 50%. The coagulant used was Fe (II) Sulphate Heptahydrate solution. The performance of MBBR was studied at the DO level of 2 mg/L and HRT of 6 hours. The phosphorous removal efficiency was found to be greater than 75%. The highest removal efficiency was observed to be 92%. In the study by Wang, (2006), it was shown from the results of the average concentration of NH^{4+}, NO^{3-} and NO^{2-} and their removal efficiencies that the efficiency of nitrification could reach to more than 90% when the DO was kept greater than 2 mg/L. It was further stated that the average TN removal efficiency of 89.9% from domestic wastewater could be attained at DO of 2 mg/l. It has been considered that DO diffusion through the biofilm rates the determining step for media nitrification.

Chu & Wang (2011) investigated the performance of MBBR for the removal of organics and Nitrogen from wastewater with a low Carbon Nitrogen ratio using the two different materials as carrier for their research, namely PUF and biodegradable polymer PCL particles. The study demonstrated that the MBBR with PUF had good results in the TOC and ammonium removal, 90% and 65%, compared with 72% and 56% for reactor filled with PCL carriers at an average HRT of 14 h. The MBBR with biodegradable PCL carrier showed good performance in terms of TN removal.

Ødegaard (2000) analyzed the influence of carrier size and shape on the performance of moving bed biofilm process related to highly loaded working plants. It was concluded that the organic surface area loading rate (g $COD/m^2.d$) is the main component for the removal of organic matter using moving bed biofilm reactor. They also concluded that shape and size of the carrier do not seem to be significant as long as the effective surface area is the same.

Kermani (2008) evaluated MBBR filled with FLOCOR – RMP® in terms of organics and nutrient removal efficiency from synthetic wastewater which showed that the MBBR could be used as an ultimate and efficient option for the total nutrient removal from municipal wastewater. The experiment shows that the system is a very effective process for almost complete organic and nutrient removal, with average soluble COD, TN removal efficiencies of 96.9, 84.6% respectively during optimum operating conditions.

According to a study carried out by Shrestha (2013) on MBBR with polyethylene carriers, the DOC removal efficiency was found to be above 92% at all filling rates. The average COD removal efficiency was at 10, 20, 30 and 40% filling rates were 75.7, 91.1, 85.5 and 79.6% respectively. These results also showed that the MBBR system achieved higher DOC and COD removal efficiency at 20% PE carrier filling rate under the same condition of influent organic loading rate.

Rodgers (2003) monitored and evaluated one novel pilot plant, a new vertically MBBR system for treating municipal wastewater for eleven (11) months. The biological carrier applied was high surface area plastic media. On-site monitoring showed that DO was in the range of 1.5 to 5 mg/L. Removal rate of filtered COD was up to 35 g COD/(m^3 day) and the bulk fluid volumetric filtered COD removal rate was 2.62 kg COD/(m^3 day). No clogging was found in the biomedia. The power consumption was in the range of 0.09–0.25 kWh/m^3 wastewater flow, 0.40–2.19 kWh/kg COD removal and 1.24–1.74 kWh/kg BOD removal. The system of pilot plant has a vertical movement of the biofilm module which supplied sufficient oxygen for the removal of the organic carbon in the wastewater. The cost for power consumption was very low. Considering that the electric driving unit consumed 4.5 kWh/ day without loading, it may be assumed that only 30% power was consumed by the actual wastewater treatment. No performance chart has been analysed. The new biofilm system offers potential for reduced reactor volumes, energy saving, simple construction and easy operation since construction cost and operation cost are two important factors in evaluating a wastewater treatment process.

Zhang (2014) conducted a trial to study nitrification kinetics of a pilot scale MBBR for treating polluted raw water. A pilot-scale MBBR with an effective reactor volume of 4.4 m^3 (1.1 m × 1.0 m × 4.25 m) was constructed at the Chongshan water treatment plant. Two factors contributed to the performance of NH_4-N removal which are temperature and nutrient loads. Oxidation rates of NH_4-N and nitrite increased with temperature, although the biomass concentrations decreased from 348.7 to 188.9 mg Volatile Solid (VS)/L as temperature increased from 16.1 to 28.3 °C. NH_4-N and Nitrite oxidation were very highly dependent on temperature, while microbial population in the biofilm was more affected by NH_4-N loading than temperature. Based on this study, the authors suggest that Polysaccharides (PS) and phospholipids (PL) and protein (PN) correlate well with VS and can be used to estimate the attached biomass in MBBR systems. In the study, nitrification performance in the MBBR was severely affected when water temperature dropped to as low as 5.0 °C.

Previous studies have proven that the MBBR has established itself as a robust and compact reactor for wastewater treatment. The efficiency of the reactor has been demonstrated in many process combinations, both for BOD removal and nutrient removal. The primary advantage of the process as compared to activated sludge reactors refers to its compactness. Also, it does not require sludge recirculation. The advantage over other biofilm processes is its flexibility, and a further study on this bioreactor can yield more results. However, all the previously mentioned methods suffer from some serious limitations. Further, most studies in the field of MBBR have only focussed on domestic, industrial and aquaculture wastewater. No previous study has been conducted focusing on multiples of biological carrier particularly for river water purification neither in laboratory nor pilot plant basis.

3. Integrated Fixed-Film Activated Sludge (IFAS)

In the 1980's and 1990's, IFAS application system work began in the United State of America (USA) especially on the integration and modification of fixed film and activated sludge technologies [13]. In proportion to today's problem like more stringent effluent requirements, high cost of reactor tank expansion and lower fund options, IFAS technology is being introduced to represent an attractive solution for wastewater applications.

Recent developments in IFAS have highlighted a few advantages for this system. One of the most common operational problems in conventional activated sludge wastewater treatment systems around the world is poor settling of biological solids although it is supported with sedimentation tank [17]. This can lead to an increase in the cost for exclusive sludge treatment, an increase in TSS concentration in effluent, and increased risks to downstream ecosystems and public health. However, based on findings reported by Kim (2010), IFAS and non-IFAS systems were likely related to the observed differences in density and settleability for the suspended phases because stable and efficient removal of the biological solids produced in biological reactors is critical to the operation of biological wastewater treatment systems for the production of high quality effluent [17].

IFAS application has been increasingly recognized as a cost effective solution for wastewater treatment process. However, the implementation, operation and performance of such systems in full scale are less reported.

3.1. Current Development of IFAS

IFAS sometimes expressed as Fixed Bed Biological Reactor (FBBR) since it media was installed with fixed-in the reactor. Basically, biomedia in the MBBR system was freely in the reactor and in the meantime, biomedia in FBBR system is installed fixed attached operating mode in the reactor (Ye, Iii & Mcdowell 2010 in McDowell and Hubbell, 2000). An attempt have been made to compare performance between FBBR and MBBR and CAS for example Choi (2012) and G. Andreottola, R Foladori (2000). The foremost difference between the MBBR and IFAS systems is the presence of a return activated sludge flow that remains to the IFAS process.

According to Choi (2012), MBBR and FBBR were compared for biological phosphorus removal and denitrification. Results indicated that all nutrients were removed by the FBBR process compared with the MBBR process: 19.8% (total COD), 35.5% (filtered COD), 27.6% (BOD_5), 62.2% (acetate), 78.5% (PO_4-P), and 54.2% (NO_3-N) in MBBR; 49.7% (total COD), 54.0% (filtered COD), 63.2% (BOD_5), 99.6% (acetate), 98.6% (PO_4-P), and 75.9% (NO_3-N) in FBBR. The phosphate uptake and NO_3-N decomposition in the FBBR process during the denitrification phase were much higher than for the MBBR process despite being of shorter duration. Results obtained from this study are helpful in elucidating the practical implications of using MBBR and FBBR for the removal of nutrients and denitrification from wastewater.

Ye, Chestna (2010) in their case study in IFAS wastewater treatment Hopedale, US able to maintain DO level in range 4-6 mg/L to provide sufficient aeration process for both process and mixing requirement. Types of aeration used are tapered aeration. After three month start-up operation, Effluent NH_3-N is consistently below the limit. However, the NH_3-N removal capacity provided by the attached growth on the media was able to keep the plant within the NH_3-N limit even with a concurrent wastewater temperature as low as 7-9^{o}C. The recovery of the system from the peak conditions appeared to be instantaneous, which had attributed to the attached biomass inventory on the media. In addition, the installation of the structured sheet media in the aeration basins also improved the process stability due to the increased biomass inventory. Effluent BOD and TSS concentrations were averaging about 5 to 7 mg/L during the IFAS period, as opposed to 15-20 mg/L for the previous CAS process. Implementation of the IFAS system appeared to improve the overall settleability of the suspended solids. An average SVI of approximately 100 mL/g was observed in the IFAS system, as compared to 150 mL/g for the prior CAS process.

Jianchang (2010) study about biofilm performance of high surface area density vertical flow structured sheet media. The study demonstrated that the Vertical Flow (VF) media combined with the proprietary distribution media is capable of achieving complete nitrification and high-rate BOD removal for both IFAS and FBBR applications. As an essential element in the VF media system, the distribution media not only maximized the air and wastewater distribution over the entire surface area of the media, but also optimized the airlift pumping through the VF media for sufficient mixing and effective biomass control. Favourable kinetic rates for example tertiary ammonia rates up to 1.4 g NH_3-N/m^2-day at 15^{o}C, SCOD removal rate of 30 g SCOD/m2-day at a SCOD load of 45 g SCOD/m^2-day, and pre- denitrification rates of 1.0-2.0 g NO_3-N/m^2-day have been consistently observed in the VF structured sheet media system, mainly due to the intimate contact between thin biofilm and substrates/oxygen as promoted by the dedicated aeration associated with the media towers.

Previous studies reported that the integrated fixed-film activated sludge (IFAS) with a media of extruded high density polyethylene demonstrated higher removal efficiencies of 90%, 90% and 85% for COD, TP and ammonia, respectively, with a solids residence time (SRT) of 8 days. Recently, performance of a hybrid activated sludge/biofilm process for wastewater treatment in a cold climate region. One of the biofilm support media for IFAS is generally made of plastic. They use various forms/types of plastic, such as polyethylene (PE) and polypropylene (PP) [22], [23]. However all the previously mention case study suffer from some serious drawbacks. Data on the effects of IFAS systems on biomass settleability are scarce and inconsistent[17]. Authors suggests that optimization of nutrient removal process should be taken into consideration for good settling character in designing IFAS system. The potential effects of IFAS on settleability in non-nutrient removal systems should be the subject of future research.

3.2. Experimental Study on IFAS and MBBR

It is essential to know about previous experimental methodology on extensive biological carrier support in MBBR and IFAS system. In order to achieve the study objectives, the methodology must be done in laboratory basis. A few factors need to take into consideration for laboratory experiment in water and wastewater treatment. The important factors are design Hydraulic Retention Time (HRT), reactor size, biomedia size, influent type and types of biological carrier. As for biological performance in biomedia, biofilm and biomass analysis and observation from previous studies also will be highlighted in this section.

3.2.1. Design HRT

Hydraulic loading is important factor. On the one hand, hydraulic loading directly determine HRT of the reactor, further influence the size of volume, on the other hand, hydraulic loading directly affect the removal effect in biofilm process [24]. So, choosing appropriate hydraulic loading is necessary. Table shows HRT and Feeding Value from previous MBBR and IFAS studies. Many of studies tested various HRT for their experimental analysis. Most of their laboratory operated in parallel and fed from a common feed tank by a multichannel peristaltic pump.

Table 1: HRT and Feeding Value from previous MBBR and IFAS study

Process	**HRT (hrs)**	**Feeding value (mg/l)**	**Location**	**Reference**
MBBR	5,10 & 15	COD:120-150	Spain	(Calderón , 2012) [25]
SBR	4	COD: 641	Iran	(Moghaddam & Sargolzaei, 2014)[26]
Fixed Media Submerged Biofilters	1.5	COD : 270-300 NH_4-N : 30-35 TN : 35-40	China	(Guohui, 2012) [24]
Hybrid MBBR	12	COD : 600	Sweden	(Falås, 2013) [27]
MBBR	24	NH_4-N : 40-50	Italy	(Bertino, 2010) [10]
Lab MBBR	4-8	COD : 500, 1000, 2000, 4000 & 8000	Turkey	(Aygun, Nas, & Berktay, 2008) [28]
Real MBBR	9 & 12	NH_3-N: 600	Spain	(González-Martínez et al., 2013) [29]
Lab IFAS	1.9-13.6	Total Kjeldahl Nitrogen (TKN) : 25-70	USA	(Regmi et al., 2011) [30]
Lab IFAS & MBBR	1-2	NH_3-N : 30-35	USA	(Ye, Kulick III, et al., 2010) [18]

Low strength feeding water test normally have low HRT in range 3 to 12 hrs. High strength feeding water and anaerobic treatment acquire longer period of HRT. However, HRT setup is be subject to researcher's objective and experimental design factor.

3.2.2. Types of Influent

Influent concentration for experimental test normally are depends on the objective and expecting results. It is under a controlled range of parameter like pH, BOD, COD, TN and other parameter. Table 2 show the types of influent sources for MBBR and IFAS study.

Table 2: Influent sources for MBBR and IFAS experimental and pilot plant studies

No	**Author**	**Location**	**Influent Source**	**Influent (mg/l)**	**Output**
1	(Leyva-Díaz et al., 2014)□[31]	Spain	Urban WW	BOD_5: 100-200 COD: 200-400	The hybrid MBBR–MBR showed the best performance of COD and BOD_5 removal as compare to pure MBBR–MBR.
2	(Gong et al., 2012)□[32]	China	Rural domestic WW	COD: 150-300 TN: 60-90	TN was removed averagely by 69.3% and under internal recycling ratio of 200% and less proportions of biomass assimilation (less than 3%).
3	(Nguyen et al., 2014) [22]	Korea	Domestic WW	TN : 30-50 COD: 150-300 TSS: 175-460	NH_4-N was completely eliminated and T-P removal efficiency was also up to 100%. It was found that increasing in internal recycling ratio could improve the nitrate and nitrogen removal efficiencies. TSS after treatment was < 5 mg/L
4	(R. C. Wang, Wen, & Qian, 2005)□[33]	China	Synthetic WW	Glucose: 200	The optimum carrier concentration was about 50% with the average COD and ammonia removal rate about 70% and 30%, respectively
5	(Shore, M'Coy, Gunsch, & Deshusses, 2012)□[34]	USA	Municipal and Synthetic WW	NH_3-N: 10-15 TN : 10-15	Experiment able to remove more than 90% of the influent ammonia (more than 19 mg/L NH_3–N) in both the synthetic and industrial wastewater.
6	(Pfeiffer & Wills, 2011) [35]	USA	Hatchery Aquaculture WW	pH: 7.3-7.5 Nitrite: 0.2-0.5	The TAN removal rates for the MB3 media was the highest of the three media types at both the low and high feed load rates averaging 12.3% and 14.4%, respectively.
7	(Clifford, Forde, McNamara, Rodgers, & O'Reilly, 2013) [36]	Ireland	Synthetic WW	COD: 0.6 TN: 0.2, and NH_4-N: 0.11 in g/m^2/day	The average removal rates 92.4%, 34.8&, and 98.5% for COD, TN and NH_4-N, respectively

Overall, average value from Table 2 shows all the influents from municipal wastewater. Average suitable influent values for experiment study are COD in range 200-250 mg/L and BOD 100 mg/L. The role of influent value is not only to provide feeding load for biomedia to treat the wastewater but also to load nutrient for attached microorganism to form a biofilm layers.

Ødegaard and Rusten (1995) gathered data from various small full-scale wastewater treatment plants and the MBBR systems started to develop. However, later, organic matter removal MBBR treatment systems were developed. Currently, MBBR systems are used as stand-alone treatment solutions and in tandem with other treatment processes including AS and membrane bioreactors for high strength organic wastewaters MBBR processes.

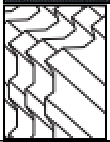
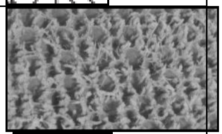
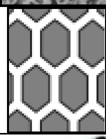
Brinkley John in Borkar (2013) investigated processes that would treat variable high strength wastewater in a small footprint and provided provisions for future expansion. He selected the MBBR process due to the success the process had for treating high strength wastewater for comparable pharmaceutical applications. The 0.5 million gallon per day (mgd) MBBR process consisted of two reactors operated in series designed to treat an influent and effluent BOD_5 of 3,197 mg/L and less than 75 mg/L, respectively.

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. according to [38] attached microorganism based process like MBBR and IFAS are suitable for high strength wastewater. however there are still study to test workability of MBBR in river water [39]. However in water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from contaminated river water[40].

3.2.3. Biological Carriers in MBBR and IFAS

The media on which the biofilm develops are carefully designed with high internal surface area having density slightly less than the water so that it can easily float. The most commonly used solid surface for attached growth processes are; stones, clinker, sand, activated charcoal, ceramic, metals, plastic sheets, and foams. There are different types of media which can be used as a media for the microbial growth[7]. Specific surface area (SSA) is the main factors that contribute the biomass characteristic in water treatment and as well as the total performance of IFAS and MBBR system. Table shows the types of carriers available in the markets and being apply in laboratory and pilot plant study for both MBBR and IFAS system.

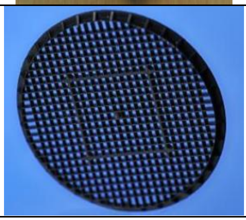
Table 3: MBBR and IFAS biological carriers that has been used in various study

Authors	**Country**	**Types**	**SSA (m^2/m^3)**	**Volume concentration**	**Figure**
Brentwood, 2009 [41]	USA	PVC Structured Sheet Media	160	75-100%	 
Brentwood, 2009 [41]	USA	Fabric Web	100	75-100%	 
Kim., 2010; Shore., 2012 [17], [34]	USA	Bioportz™	576		
Azimi, Hooshyari, Mehrdadi, & Bidhendi, 2007 [42]	Iran	Bee-Cell 2000	650		
Borkar et al., 2013 [37]	India	Chips	260		
Zhang et al., 2013 [16], [43]	China	Yuhuan	230		
Bio, 2005[44]	USA	ActiveCell™	400	50-70%	

Continue Table 3..

Authors	Country	Types	SSA (m^2/m^3)	Volume concentration	Figure
Aygun et al., 2008; Bertino, 2010; Calderón et al., 2012; Jaroszynski, Cicek, Sparling, & Oleszkiewicz, 2011; Leyva-Díaz et al., 2013, 2014; Pfeiffer & Wills, 2011; Daniele Di Trapani, Mannina, Torregrossa, & Viviani, 2010 [10], [25], [28], [31], [35], [45]–[47]	USA, Turkey, Canada, Spain & Italy	Anodkalness™ K_1	500	50-70%	
Hoang et al., 2014; Regmi et al., 2011; Bjorn Rusten, Kolkinn, & Odegaard, 1997 [30], [48], [49] [12][30], [48], [49]	USA	Anodkalness™ K_3	500	50%	
Chu & Wang, 2011 [12]	China	Polyurethane foam (PU)	900	30%	
Xie et al., 2005; Zhu, Yu, Wu, & Yao, 2014 [39], [50]	China	Bio-ceramic	2500	50%	
Chu & Wang, 2011 [12]	China	Polymer polycaprolactone (PCU)	346	70%	

Continue Table 3..

Authors	Country	Types	SSA (m2/m3)	Volume concentration	Figure
Pfeiffer & Wills, 2011 [49]	USA	MB3	604	-	
(P. Wang, Wang, Ai, & Yang, 2011 [51] [13]	China	Cageball	300	40-50	
Kermani et al., 2008 [50],	Iran	Flocor RMP-HPS®	277	70	
Aloysius, 1999; Hussain, Tat, & Idris, 2014 [52], [53]	Malaysia	Cosmoball ™	160	100	
Falås et al., 2013 [27]	Sweden	Biofilm Chip M ™	500	-	

3.2.4. Aeration rate

In MBBR and IFAS system, aeration is used to provide DO for the biomass and also to create the cross flow velocity to scour the biomedia surface [8]. The high crossflow activities that are generated at the biomedia surface tend to shear off the deposited materials and thus reduce the hydraulics resistance of the fouling layer. An optimum value of air flow rate was identified beyond which further increases had no effect. The similar phenomenon was also verified by some researchers [32], [38], [54]. Wang (2012) investigated the effect of hydrodynamic on biomedia and concluded that the treatment filtration rate sharply increased at aeration intensity below the critical aeration intensity.

4. **Conclusion**

There are varieties of biomedia used in river water purification technologies which are available in the local and international water industry market nowadays, and the types of biomedia can be characterized by considering the types of treatment system. Different types of biomedia have their unique performance based on certain treatment conditions. Apart from biomedia removal efficiency and physical characteristics at the allocated design flow, other important aspects that affect the decision in selection of biological carriers for MBBR and IFAS are frequency of maintenance and cost. Biomedia should be able to provide a habitation for the growth of the attached microorganism which is called biofilm layer, either fixed or freely moving inside the river purification system. Based on previous studies, Biomedia in MBBR and IFAS have been widely tested only for domestic sewage or industrial wastewater including aquaculture wastewater. However, approaches of this kind carry with them various well known limitations. There have been no controlled studies which compare differences between biomedia physic-chemical and biological performance for river water treatment plant in local tropical river condition. However, the research concluded so far are compiled herein and reported for the first time to acquire a better perspective and insight on the subject with a view of meeting the news approach. To this end, the most feasible technology could be the combination of advanced biological process (bioreactor systems) including Moving Bed Biofilm Reactor (MBBR) and Integrated Fixed Activated Sludge (IFAS) system.

Acknowledgments

This research is a Fundamental Research Grant Scheme (FRGS/1/2014/STWN01/UNITEN/03/1) supported by Ministry of Higher Education Malaysia under the title “Gross Pollutant Characteristic Using Economic Analysis For Stormwater Treatment Alternatives Decision Making in Tropical Climate Country” with the collaboration of several Higher Educations Institutions and Government Sectors.

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