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CONVENTIONAL METHODS AND EMERGING TECHNOLOGIES FOR URBAN RIVER WATER PURIFICATION PLANT: A SHORT REVIEW

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ABSTRACT

Obviously river water purification processess are considered as a new approach and their implementation and application are at fundamental basis but there are still current treatment technologies being researched and the outcomes maybe available in a while. This review paper present the various methods for urban river water purification including both conventional methods and new emerging technologies.The review also includes many relevant researches carried out at the laboratory and pilot scales. In river water purification process, biological-advanced technologies and other physicochemical methods are gaining much attention. While previously most treatment of river water have been carried out in conventional direct and bypass treatment, in recent years, here are many emerging technologies can be adapted for river water purification. Until recently, multivariable resources have not been available for researchers to have a rich supplementary data to synthesize and digest since river purification project is new and still in its beginning phase in developing countries. There are still current treatment technologies being researched and the outcomes maybe available in a while. 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. Afterward, 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, followed by solid separation prior to discharge.

Keywords: river water purification, urban river, physical-chemical water treatment, biological water treatment process.

INTRODUCTION

By the early 20th century, there are almost no completely natural rivers in the world. Distinctive river water quality is very important for all living beings. We cannot change our river water dependency even with modern technologies. People become concerned when water source becomes scarce and less secure. The problems of urban river pollution and ecological damage are becoming more critical due to increased environmental stressors. In developing countries, urban rivers are primarily polluted with organic substances attributable to domestic and industrial activities due to inadequate sewage systems and other pollutions. In Malaysia, a lot of effort on research and development had been implemented toward to mitigating river pollution.

In Malaysia, The River of Life (RoL) project is a government initiative that aims to transform the Klang River into a vibrant and liveable waterfront with high economic value. This transformation is divided into three components: river cleaning, river beautification and land development. 46 work packages for river cleaning works have been planned by Department of Irrigation and Drainage. Of these packages, 18 are already under construction mainly for the initiatives to utilise retention ponds and remove pollutants from sewage, to implement the Drainage and Stormwater Management Master Plan to upgrade drainage systems, to install additional gross pollutant traps, and to construct new communal grease traps, amongst others. River cleaning will be conducted along a 110 kilometre stretch along the Klang River basin, covering the municipal areas of Majlis Perbandaran Selayang (MPS), Majlis Perbandaran Ampang Jaya (MPAJ) and Dewan Bandaraya Kuala Lumpur (DBKL). The goal is to bring the river from its current Class III – Class V water quality (not suitable for body-contact) to Class IIb (suitable for recreation) by year 2020 (Performance Management and Delivery Unit (PEMANDU), 2012).

Previous reviews have been published emphasizing the current conventional river and wastewater treatment methods and state-of-the-art laboratory treatability studies. Some papers emphasize green and natural technologies to attempt sustainable technology. As current scenario in river water purification focuses on biological treatment towards the challenging Class II for River Water Quality Index Status, this paper aim to concisely review and report the available river water purification effort either conventionally or emerging technologies available.

RIVER WATER PURIFICATION MEASURES

Major literature in river purification and restoration are originated from developed countries. The data collected and experiences in every river subjects help us understand its workability for local river conditions and to develop localized river purification design guidelines.

Gu *et al.* (2014) study the implementation of Soil and Water Assessment Tool model on Upper Mississippi River Basin (URMB), USA. This model is to simulate and evaluate the impacts of two bio-fuel crops on nonpoint source pollution. The results of this study can assist in cost-benefit analysis and decision-making in environmental management in large-scale agricultural areas. Another study, Mamun & Zainudin (2013) argues about the reliability, validity, accuracy of the Water Quality Index execution in Malaysia. The authors summarize current Malaysian river status and legislation approach and also the scenarios in river management in Malaysia. They suggest to the local government to implement the evaluation of river water quality to a more holistic approach. Introduction for alternatives methods to measure river water quality such as Harkin's objective index, Shannin Wiener diversity index (H), SCI diversity index, Index of biotic integrity (IBI), Index of Saprobic condition (S), and others.

Woo (2010) reported that river ecological control is very crucial by utilizing scientific knowledge on the processes of aquatic ecosystem degeneration and a methodology for solving the ecological problems in artificially altered rivers currently under development. It followed by the introduction of a near-prototype experiment facility recently completed mainly for research on ecological river engineering. Basic research progresses in succeeded eco-river in Korea consist of flow resistance due to vegetation, environmental flow, floodplain vegetation modelling, small dam removal and finally river restoration process.

Latip *et al.* (2012) discussed on River of Life Project which is on-going developed at Sg. Klang and its tributaries. The research focus on architecture modelling approaches especially for infrastructure and structural projects for ROL projects. The technique adopted is field observations and for building subject, the techniques used are survey and time interval observation approach. From the result, all research zones have medium level of contextual integration and factor influences are based on positioning location factor, accessibility and the provision of space and facilities.

P. Wang *et al.* (2011) points out that rapid economic development, the problems of water pollution and pollution-induced water shortage in Taihu Province, China. In order to improve Wangyu River Water Quality, ecological spur-dike has been used. Biofilm characteristic has been analysed using the changing process of microbial community after 39 days of operation. Three (3) sites of water samples are observed their water qualities which are at before, behind the spur-dike, and in the background of Wangyu River. Results show that 70 taxa of attaching organism were identified on the biofilter, Major divisions are Bacillariopyta 37, Chlorophyta 20 and Cyanophyta 7. The purification efficiency of SS, TP, TN and COD were at the range of 5.1%-61.2%, 16.4%-57.2%, 8.2%-17.7%, 1.6%-34.5%, respectively.

Zhang *et al.* (2010) carried out an investigations into the purification situation of different media to the corresponding polluted components in the downstream of Yitong River in Changchun China. The polluted water samples and different media which fit the dualistic structure of Yitong River are collected in the experiment. The soil columns are used in experiment to simulate the purification capability under nature conditions. According to series of soil samples analysis and water sample tests, the regularity of filtering purification capability patterns of different media to polluted water are produced. The results provide scientific proof for predicting the development of groundwater pollution. Yet, the generalizability of much published results on this paper is problematic. The objectives, results and conclusions are not clear and not synchronized as the researchers have not treated media purification performance in much detail.

Xie *et al.* (2005) use laboratory experiment to test the performance of biological pretreatment in Yellow River, China. A parallel pilot plant between bio-ceramic filter (BF) and Moving Bed Biological Reactor (MBBR) filter has been run and the results indicated that BF has higher NH3-N, Trihalomethane (THM) and Total Organics Carbon (TOC) removal compare to MBBR. MBBR has higher diatom and cyanobacteria removal than BF. These finding is important in terms of initials idea for MBBR, river purification and laboratory setup. Besides that in another reference, MLIT (2003) can be consider as a complete manual and guidance to researcher specialty on water quality improvement, water quality conservation, direct river purification guidance, lake and reservoir measures.

Wang *et al.* (2012) summarize the researches on river pollution control and remediation. The methods have been approached are physical remediation, chemical remediation and bioremediation. After compared and analysed with different techniques and clarified the concepts of bioremediation technology, based on the advances of river remediation. Basically this paper highlights the approaches to alleviate the river pollution problem. Additionally, the biological ecological remediation should be utilized as the primary technique and also the physical and chemical remediation as the supplementary means.

Tian *et al.* (2011) found that the capacity of self-purification of the river may act as one of the indicators in regulating the discharge standards. Three reaches in Juma River were selected including serious polluted, light polluted and clear reach. Samples of water and aquatic plants were taken for the pollutant test. The results indicate that Juma River has a great ability to purify the organic pollutants such as TN and TP, but little ability for the heavy metal ions. Based on the analysis on pollutant absorption ability of the three aquatic plants, Myriophyllum spicatum has the greatest ability to absorb the organic pollutants. Ultimately, river water improvement research in Malaysia by Lariyah *et al.* (2013) described a long term project which aimed to provide new tools, techniques and procedures to enhance rivers located in urban areas in Sg. Penchala catchment. This study provides the best and most innovative practice to develop a comprehensive urban water management study that will achieve the "maximum ecological potential" requirement.

River Water Purification Plant Components

River Water Treatment Plant (also known as river purification) is considered as direct river treatment plant.

In Malaysia, River water purification is considered as a new approach and the implementation is still at fundamental basis. Currently, water quality improvement efforts are focused primarily on point source measures such as sewerage treatment, pertinent regulation and wastewater treatment. Japan and Korea have implemented this treatment technology about decade ago. Figure-1 shows the concept of river purification measures which are being implemented in Japan, China and Korea. These river basin efforts are enormously expensive (MLIT, 2003).

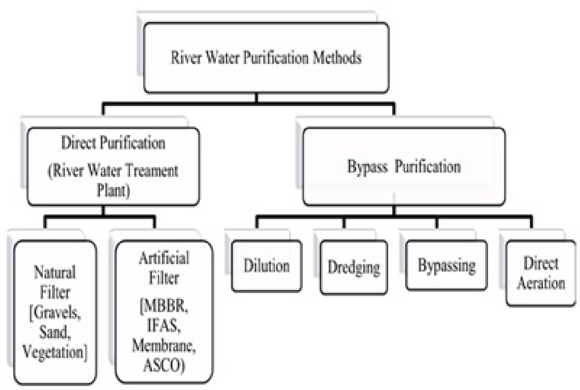

Figure-1. The concept of river purification process (MLIT, 2003).

Direct Purification

MLIT (2003) has described the process of direct purification that consists of direct and bypass purification. Polluted river water is conveyed to a water purification facility which then returns the decontaminated water to the river and directly reduces pollutants at the facilities. A previous research attempt has been made in natural purification situation of different media to the corresponding polluted components in the downstream of Yitong River in Changchun China. This experiment used the soil as media to simulate the purification capability of the river water under natural conditions. F. Zhang *et al.* (2010) analyzed series of soil samples and water sample tests, and the regularity of filtering purification capability patterns towards types of media to polluted water. In real river purification project in China, an ecological spur dike was constructed in Wangyu River before the water is diverted to Taihu Lake for drinking water purpose.

Artificial filtrations are also mostly applied in river purification projects. Artificial biological filter are originally adapted from wastewater treatment plant technology. The evidence of artificial filter can be clearly seen in the application of MBBR, ASCO and IFAS systems. In broad water industry term, MBBR is an upgraded activated sludge with suspended biological carrier in a complete mix and continuous flow which combine attached growth process and suspended growth process (Metcalf & Eddy, 2003; Pastorelli, 1999; Qiqi, Qiang, & Husham, 2012). On the other hand, IFAS is a hybrid suspended growth- biofilm system that incorporates a high surface area of fixed or free floating media in oxygen deprived or enriched zones of the conventional activated sludge process (CAS) (Mahendran, Lishman, & Liss, 2012).

Bypass Purification

In the river, dilution process is able to improve polluted water quality. It introduces an entry of clean water from a tributary into a polluted main river thus increasing the flow volume of main river proportion to the introduced water quantity. In a tidal river, this method improves water quality by the alternating tidal current regime due to reverse flow of tidal river and the increment of DO in the water. This method involves moderate expenses for constructing diversion and conveyance facilities including operation cost. During low flow, the water quality is adversely affected due to inadequate dilution and makes the water unacceptable or costly to treat (Mamun & Zainudin, 2013).

In developing countries, this method would be harder to apply because of the difficulty in securing a steady supply of clean drinking water (MLIT, 2003). In China, dilution reduces the ecological toxicology risk in the Yangtze River but it does not eliminate the toxic pollution (Floehr *et al.* 2013). From the results from the study, it has been proven that dilution is able to reduce emerging level of pollutants originating from effluent treatment plant and is also able to meet the emerging pollutant level standard guidelines. As a consequence, this method is reliable for water quality improvement after considering all design and operation factors.

Other than water quality improvement, dredging carried out the prevention of river bed aggradation in estuaries and the main maintenance of navigation channels. There are a few dredging projects carried out under Jabatan Pengairan dan Saliran Malaysia (JPS). The dredging of riverbeds has been practiced for many years to maintain the necessary cross section of the river channel in certain areas. Riverbed sludge which has various adverse effects, for instance producing offensive odours, spoiling the appearance of rivers due to bottom mud stirred up by flowing water, reduced DO level in the river and dissolution of pollutants (Department of Irrigation and Drainage Malaysia, 2012)

In the bypassing method, a tributary or drainage channel causing pollution of the main river is bypassed through a newly constructed channel or conduit, so as to conserve the water quality of the main river. This method is typically used for rivers of a water supply source. This method necessitates the construction of a new channel or conduit for a polluted tributary. So far, this method has been used only for major rivers due to many restrictions; for instance the method is effective only after a new channel or conduit is completely constructed and consider as expensive as well. Bypassing is surely one viable option if the factors and realities of river pollution are clearly known and bypass construction and operation do not cause problems (MLIT, 2003). Bypassing method is not only for conserving the surface water quality but also function as flood control measures and fish passage way in dam facilities in the upperstream.

The method of purifying river water, specifically by enhancement of the self-purification capability of rivers, should be used only after the river improvement and environmental water quality improvement projects have widely been carried out. Direct aeration of river water to improve the DO level of rivers is another means of tropical areas to have a low DO level and to be anaerobic, and so direction aeration would be useful means of mitigating the anaerobic conditions. Presently, the utility of river aeration technology has relatively been mature in foreign countries, and the research and practical applications showed that the artificial aeration can improve water quality effectively.

The river aeration technology has been used successfully in the treatment of the Oeiras River in Portugal, the Emsche River in Germany, Thames River in UK and Homewood Canal in U.S (Sanders, Yuan, & Pitchford, 2013). The aeration equipment was utilized in the treatment of the Homewood Canal of U.S. in 1989, which increased the dissolved oxygen in bottom water and by which the biomass of river became enriched. The river aeration was used to improve the river water quality effectively in Germany in 1994. The river aeration technology was used to eliminate the phenomenon of bad-odour of water thoroughly in Busan, South Korea (Sohn & Division, 2006).

Xiasheng (1990) concluded that when the water body is contaminated, the river can purify itself by some physical and chemical actions such as flowing, dilution, deposition and adsorption which are called the self-purification. Hanelore, (2013) emphasized that in some cases, river contamination happenes quickly and to a much higher degree that exceeds the capacity of river water to recover which could give adverse effects to its ability to self-purify. Self-purification is the process in which balanced restoration of the aquatic environment takes place through simultaneous participation or in some sequence of the physical and chemical factors, biological, hydraulic and morphological characteristics of the river (M. Hanelore, 2013).

The Concept of Wastewater and Water Treatment Process

Since 1990s, water authorities have kept pace with the growth in population and its water requirements. However, in recent years the gap between supply and demand has grown and the marginal costs of providing additional supplies are rising suddenly (Mekala *et al.* 2008 in Shrestha, 2013). Many treatment technologies have been introduced to fill this gap of demand and supply in an economical ways. Some of these technologies are described in this section.

Wastewater can be treated by physical, biological, and chemical treatment methods in different steps; preliminary, primary, secondary and tertiary (Shrestha, 2013). The type and order of treatment may vary from one treatment plant to another according to the wastewater type. In preliminary treatment stage, all the big particles like grit, rags, leaves which can damage the equipment are removed. From the primary treatment stage, floating and settleable solid materials in wastewater are removed by sedimentation process or by adding some chemicals to enhance the removal of suspended and dissolved solids. In secondary treatment stage, biological and chemical processes are used to remove most of the organic matters from the wastewater. From the tertiary treatment stage, residual suspended solids and other constituents that cannot be removed by secondary treatment are removed by using an additional combination of physical and chemical processes (Metcalf & Eddy, 2003).

Physical-Chemical Water Treatment Process

Physical-chemical treatment of wastewater focuses primarily on the separation of colloidal particles. This is achieved through the addition of chemicals which is called coagulants and flocculants. This change in the physical state of the colloids will allow them to remain in an indefinitely stable form and therefore forms into particles or flocculants with settling properties. Clearly, the changes of biological operating conditions especially Hydraulic Retention Time (SRT) will induce the revolution of microorganism species, alteration of physicochemical and biological properties of mixed liquor, and subsequently affect membrane performance (Le-Clech *et al.* in Khor 2008). Table-1 shows the chemical-physical process for water and wastewater treatment.

Biological Water Treatment Process

Nowadays, due to increasing awareness about environmental impact of discharges, it is necessary to realize biological processes that allow complete treatment of the wastewater (Di Trapani, Mannina, Torregrossa, & Viviani, 2008). Biological treatment using aerobic activated sludge process has been in practice for well over a century. Increasing pressure to meet more stringent discharge standards or not being allowed to discharge treated effluent has led to implementation of a variety of advanced biological treatment processes in recent years (Arun, 2011). Biological treatment process is normally called secondary treatment in wastewater treatment plant.

The main unique characteristic of biological treatment process compared to other processes include air (DO) is introduced to the wastewater in the aeration tank, whereby the organics matter in the reactor are reduced to cell matter (solids) and stabilized before removing the sludge by gravity in the secondary settling tanks (Donna *et al.* 2011). There are multitudes of aerobic biological treatment processes and technologies in literature and practice. However, only six processes will be discussed in detail as shown in Figure-2.

Table-1. Description of physical-chemical process in wastewater treatment process.

Treatment process	Advantages	Limitations	References
Adsorption	Low initial cost, flexibility and simplicity of design, ease of operation and regeneration, insensitivity to toxic pollutants, avoids using toxic solvents and minimizes degradation.	High operation cost, this process just transfers pollutants from one phase to another rather than removing from the environment	(Jiuhui, 2008; Soto, Moure, Domínguez, & Parajó, 2011)
Flotation	High selectivity to recover valuables (Au, Pt, Pd, etc.), high efficiency to remove contaminants, low operating costs with the use of upcoming flotation devices, less space needs,	Required higher power connection, less flocculation flexibility and performance are controlled by the strict hydraulic control.	(Metcalf & Eddy, 2003; Rubio, Souza, & Smith, 2002)
Chemical oxidation	Produces no significant wastes except Fenton, reduced operation and monitoring costs, compatible with post treatment monitored natural attenuation and can even enhance aerobic and anaerobic biodegradation of residual hydrocarbons.	Potentially high costs, contamination in low permeability soils may not be readily contacted and destroyed by chemical oxidants, significant health and safety concerns are associated with applying oxidants.	(EPA, 1998; Renou, Givaudan, Poulain, Dirassouyan, & Moulin, 2008)
Coagulation/ Flocculation	Helps to remove suspended particles from the wastewater and make colloids or floc particles settle faster and easier to dewater.	Required rapid mixing in the coagulation process to disperse coagulant in the liquid while flocculants must be added slowly and mix in the flocculation process to prevent agglomerated particles from broken apart. Excess coagulants and flocculants can cause charge reversal and destabilize the colloid complex.	(Amokrane, Comel, & Veron, 1997; Zheng et al., 2011)
Air Stripping	Low cost, easy to install, operate and maintain, can be installed in a small area.	Air Stripping units can only take out chemicals that can evaporate. Bulky pollutant cannot be taken out.	(Srinivasan, Chowdhury, & Viraraghavan, 2008)
Chemical Precipitation	Self-operating and low maintenance, requiring only replenishment of the chemicals used, a sophisticated operator is not needed frequently	Overdosing can diminish the effectiveness of the treatment, the addition of treatment chemicals like lime may increase the volume of waste sludge up to 50%, large amounts of chemicals may need to be transported to the treatment location.	(EPA, 1998)

Aerobic treatment is the biological process in which microorganisms use free or dissolved oxygen during the biodegradation of organic pollutants. These treatment processes enhance the growth of naturally occurring aerobic microorganisms which are the main components in wastewater treatment processes. Aerobic treatment processes are based on suspended-growth biomass such as aerated lagoons, CAS. Suspended growth bioreactor, attached growth bioreactor, rotating biological contactor, trickling filter, sequencing batch reactor are the most commonly used aerobic treatment processes.

Anaerobic treatment utilizes naturally occurring bacteria to break down biodegradable material in wastewater. Reactors are enclosed or covered to prevent the introduction of air and the release of odours. The absence of oxygen leads to controlled anaerobic conversions of organic pollutants to carbon dioxide and methane, the latter of which can be utilized as an energy source. The anaerobic treatment processes include anaerobic suspended growth, up flow and down flow anaerobic attached growth, fluidized bed attached growth, up flow anaerobic sludge blanket (UASB), anaerobic lagoons, etc. They are widely used to treat high strength wastewater having a warm temperature because they generate low amount of solids and does not require aeration, thereby saving energy for the wastewater treatment.

Secondary treatment systems are broadly categorized into types of microbiological biomass dominant as followed:

- Suspended growth
- Attached growth
- Dual biological suspended and attached growth (Hybrid Growth) (Weiner & Matthews, 2003)

The biomass growth systems and its treatment technology can generally be classified as shown in Figure-2. The performance of biological wastewater treatment system depends on the total biomass concentration on the system (Jianlong, Hanchang, & Yi, 2000).

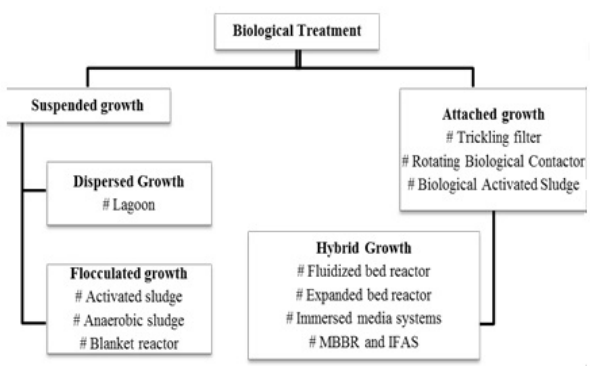

Figure-2. Biomass growth systems in wastewater treatment systems (Jianlong *et al.* 2000).

Suspended Growth Concept

Gerard Kiely (1997) mentioned suspended growth systems are those aerobic processes that achieve a high microorganism concentration through the recycle of biological solids. The free floating bacterial microorganisms convert biodegradable organic matter in wastewater and certain inorganic matter into new biomass, water and CO2. The biomass then is removed as sludge and the liquid after settling is removed as clarified effluent. There are two types of suspended growth in wastewater treatment system. As illustrated in Figure-2, suspended growth categorized into two different types; dispersed growth and flocculated growth. Based on visual observation, dispersed growths consist of individual cell or small clumps with diameter cell up to 20□m. On the contrary, flocculated growths consist of larger dimension particles which about 100□m in roughly spherical and compact form (Jianlong *et al.* 2000).

Suspended growth systems in particular the conventional plug flow activated sludge system are the most common processes for treating both municipal and industrial wastewater. Suspended growth systems however have been considered unstable, possess some inherent disadvantages e.g., washout, low biomass concentration and associated with poor water quality by the general aquaculture wastewater community (Gutierrez-Wing & Malone, 2006; Verma, Brar, Blais, Tyagi, & Surampalli, 2006)

Attached Growth Concept

Attached growth process is a biological treatment process in which microorganisms grow and build a thin biofilm layer in a specially designed inert material such as gravel, sand, peat, or specially woven fabric, plastic or sponges, while moving freely in the whole volume of the reactor by absorbing organic matter or other harmful constituents in wastewater. The basic principle of the process is that the biomass grows on a specially designed mobile carrier introduced in the reactor simultaneously with the oxidation of organic or inorganic compounds in wastewater. Certain agitation is set up in the process to make the carriers mobile by aeration in aerobic condition or mechanical mixing in anaerobic and anoxic condition.

The biofilm carriers provide a large protected surface area for the aerobic biofilm and optimal conditions for the bacteria culture to grow and thrive. These microorganisms are primarily aerobic, and oxygen is a key requirement for their survival. Raw wastewater must be treated before being supplied into the attached growth system to remove the larger solids and floating debris because these solids can plug the filter.

Attached growth processes in wastewater treatment are very effective for BOD removal, nitrification, and denitrification. The main advantage of the attached growth system is the high biomass concentration which enables stability under high organic and hydraulic loading, very high sludge residence time, lower sensitivity to toxic effects, and easier adaptation to feed pollutants. In addition, the compact size of these systems drastically reduces the capital cost while operating cost is minimal in cases where natural aeration takes place (Metcalf & Eddy, 2003).

Attached growth processes can be classified into two groups with regard to the carrier status as; fixed bed reactors and moving bed reactors. The moving bed reactors are defined as the biomass growth on small carrier materials that move along with water in the reactor for example Rotating Biological Contactor (RBC).

In the fixed film systems the media are held in place, allowing the wastewater to flow over the bed such as trickling filters. Different types of attached growth systems for wastewater treatment are summarized in Table-2. Attached growth biofilm can form aerobic zone, anoxic zone and anaerobic zone along the direction of mass transfer, providing a favourable environment for simultaneous nitrification and denitrification. It could be presumed that the biofilm can improve the total nitrogen removal in aerobic phase and inhibit the transfer of nitrate into the anaerobic phase. As a result, simultaneous nitrogen and phosphorus removal could be resolved in a single tank (Shrestha *et al.* 2013).

The basic principle of the process is that the biomass grows on the specially designed carriers that move into the reactor by the agitation setup by aeration in aerobic condition or mechanical mixing in anaerobic and

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anoxic condition. It might take a few days or months to grow biofilm depending on the feedwater organic concentration and the biomass carrier types.

Table-2. Different types of attached growth system (Odegaard, Rusten, & Westrum, 1994).

Type of attached growth systems	Comments
Trickling filter	➢ High surface area for biofilm attachment ➢ Require low power for operation ➢ Require large space
Rotating Biological Contactor (RBC)	➢ High surface area for biofilm attachment ➢ Mechanical failure frequent
Fixed Media Submerged biofilter (IFAS)	➢ High surface area for biofilm attachment ➢ Simultaneous biological treatment and suspended solid removal ➢ Poor nutrient loading distribution in bioreactor
Granular media biofilter	➢ Simultaneous biological treatment and suspended solid removal ➢ Require backwashing
Fluidized bed reactor	➢ Highest volumetric rate for carbon and nitrogen removal ➢ Stability for shock loading ➢ Hydraulic instability and expensive
MBBR	➢ Good oxygen transfer ➢ Auto-regulation of biofilm thickness ➢ Simple distribution of liquid flow that enable raw unsettled wastewater to be treated directly.
Hybrid bed filter	➢ No need for high rate effluent recirculation and concomitant pumping energy ➢ Maximize biomass concentration in reactor ➢ Increase cost to the system due to added support media.

Table-3. Summary of performance of water and wastewater process using attached growth.

Process	Removal Efficiency		Location	Reference
	TN	COD		
Integrated anoxic-oxic biofilm reactor	38-42	60-78	China	Gong et al., (2012)
Intermittently aerated MBBR	47–55	42–67	Finland	Luostarinen et al., (2006)
Filter packed with recycled glass	10-26	72-83	Ireland	Gill *et al.* (2009)
Integrated step-feed biofilm process	25-75	80	China	Liang et al. (2010)
Reactive bed filter packed with Polonite	17.7	-	Sweden	Renman et al. (2008)
Hybrid bioreactor	59.1	93.6	Korea	Hong et al. (2005)
Reed bed	38-66	-	Australia	Davison et al. (2001)
Suspended carrier biological reactor (SCBR)		70	China	R. C. Wang, Wen, & Qian, (2005)
Moving bed biofilter systems	-	50-70	USA	Pfeiffer & Wills, (2011)
Nitrification-Annamox	85	-	Sweden	Bertino, (2010)
Annamox	-	35-85	Singapore	Khor, (2008)
MBBR	89.1	-	China	X. J. Wang et al., (2006)

Table-3 portrayed above show the performance of attached growth application system obtained from different studies. The removal efficiency of Total Nitrogen (TN) and COD are highlighted. Contradiction results obtained from different study due to large differences in feeding wastewater and biofilm behaviour. Apart from that, the monitoring periods of each study are differed. Some results are drawn from long term monitoring while others are short term. Overall results show outstanding performance result with overall removal efficiency are more than 50% while the experiment only operated in s short period of time

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.

CONCLUSIONS

Increasing concern about NPS transported to the urban waterways resulting in the degradation of the water quality and also reducing aesthetic values has resulted in the implementation of structural and non-structural measures by local authorities. RWTP has been introduced as a structural measure to purify the polluted Klang River under ROL project. There are varieties of biomedia used in RWTP 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. Although not many studies have highlighted specifically about detailed technical support for river purification, our findings concludes that river purification measures still have a big gap to explore. Until recently, multivariable resources have not been available for researchers to have a rich supplementary data to synthesize and digest since river purification project is new and still in its beginning phase in developing countries. There are many treatment technologies had emerged and the outcomes maybe available in a while. 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, followed by solid separation prior to discharge.

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