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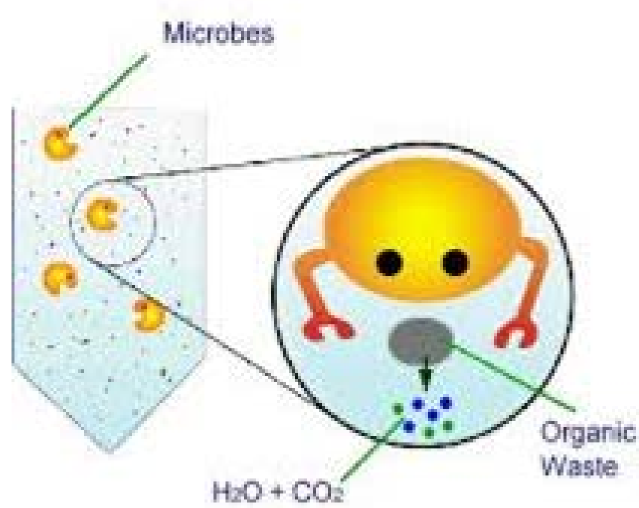
Application of appropriate bioremediation strategies for water obtained from secondary water treatment tank



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1. Background

1.1 Introduction

Bioremediation is the use of microorganisms to degrade environmental contaminants into less toxic forms (Heerden et al., 2010). Research has demonstrated that bioremediation can be an effective solution to tackle waste water due to the capability of microorganisms to survive, adapt, and thrive within many environments, including wastewater (Palma et al., 2017; Sharma and Khan, 2013; Singh et al., 2016; Wuang et al., 2016). Bioremediation strategies for wastewater are often more beneficial than traditional strategies since it can be implemented directly at the site of the contaminant or in the wastewater treatment plant. Wastewater is a big problem in many countries; therefore, bioremediation for waste water treatment is one of the best solutions to tackle the problem.

Figure 1.Ho Chi Minh City, Vietnam. (Van Buuren and Potting, 2011)

Ho Chi Minh City is located in the South-Eastern part of Viet Nam, consisting 24 districts with a total area of 2,095,006 km^2 (Verma et al., 2016). In term of population, Ho Chi Minh City is greater than Hanoi, the capital city of Viet Nam, with a population of 7.98 million (more than 8 percent of the country) (Statistical Handbook of Viet Nam, 2014). With this large population compared to other cities in Vietnam, the generation of solid waste in Ho Chi Minh City is also greater than in other cities. The Government of Ho Chi Minh City has been focusing on developing water management strategies, particularly in wastewater management, as well as water supply, drainage, and sewerage systems, to meet the needs of the growing population and achieve its targets for sustainable urban development. The aim of this research is to apply appropriate bioremediation strategies for water obtained from secondary water treatment tanks. The result will be water recycled from water treatment plant (WTP) that can be used for domestic/commercial purposes (Figure 1).

Figure 1: Water treatment plan of Ho Chi Minh City

1.2 The treatment of wastewater in Ho Chi Minh City

While the economy of Vietnam has grown rapidly since the 2000s, pollution of the water environment has been a serious issue. Especially in urban areas, construction of large capacity sewage treatment infrastructure has been an urgent requirement.

Even though Ho Chi Minh City has a large area and population, there is only one wastewater treatment plant constructed and operated within the city. Some information about the wastewater treatment plant can be seen in the following picture (Figure 2).

Figure 2: Waste water treatment plant operating in Ho Chi Minh City

However, the current wastewater treatment plant is unable to treat the majority of wastewater generated in the city. Currently, only 10 percent of the wastewater in the city is treated in the WTP. However, the growth in infrastructure and urbanization in the city is increasing the amount of wastewater generated.

From the perspective of wastewater treatment technologies in the wastewater treatment plant, bioremediation is missing in the system and hampers the process of wastewater treatment. Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site. Bioremediation may occur on its own (natural attenuation or intrinsic bioremediation) or may only effectively occur through the addition of fertilizers, oxygen, etc., that help in enhancing the growth of the pollution-eating microbes within the medium (biostimulation). There are a number of cost-efficient advantages to bioremediation, which can be employed in areas that are inaccessible without excavation. For example, hydrocarbon spills (specifically, petrol spills) or certain chlorinated solvents may contaminate groundwater, and introducing the appropriate electron acceptor or electron donor amendment, as appropriate, may significantly reduce contaminant concentrations after allowing for acclimation. This is typically much less expensive than excavation followed by disposal elsewhere, incineration, or other ex situ treatment strategies, and reduces or eliminates the need for "pump and treat" practices, which are common at sites where hydrocarbons have contaminated clean groundwater. Using archaea for bioremediation of hydrocarbons also has the advantage of breaking down contaminants at the molecular level, as opposed to simply chemically dispersing the contaminant.

Taking the increasing demand for high quality water resources into consideration, the recycling of water for some purposes can be adopted as a solution in developed countries. In the near future, with the rapid development, it also can be considered in Ho Chi Minh City.

In this case, improving the water quality of outflows and the performance of wastewater treatment plant is urgent for Ho Chi Minh City to satisfy the demand for wastewater treatment. Therefore, bioremediation techniques can be considered as a solution for effective wastewater treatment.

2. Objectives

In order to make sure that bioremediation can be applied for water generated from a secondary water treatment tank in the treatment plant, some research should be done. The following four objectives are proposed.

OBJECTIVES:

1) To identify effective micro-organisms available to treat the water generated from a secondary water treatment plant

The current wastewater treatment plants have simple secondary treatment processes, without efficient biological treatment. The outputs of meeting this objective will be to identify wastewater treating microbial consortia.

Analysis of physical, chemical, and biological characteristics of water from secondary treatment processes, as well as identification, isolation, and characterization of microbial consortia to be used for bioremediation should be completed.

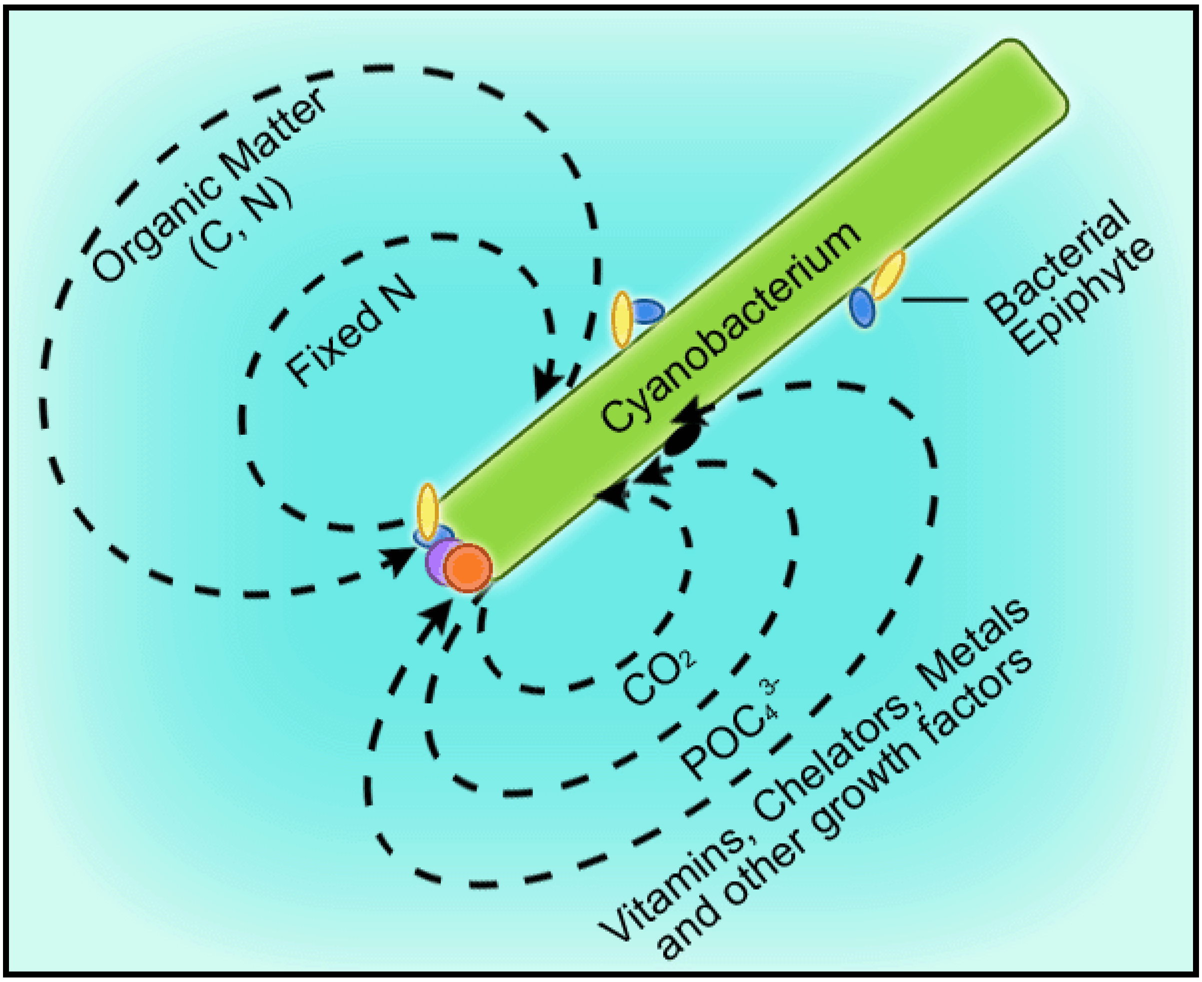
Microorganisms are of great significance in wastewater treatment. The stabilization of organic matter is accomplished biologically using a variety of microorganisms, including bacteria, viruses, and protozoa. These organisms can metabolize the biodegradable organics, and convert them into carbon dioxide, water, and energy for their own growth and reproduction.

So in order to identify the most effective micro-organisms available to treat the water generated from the secondary water treatment plant, the characteristics of each kind of microorganism and the quality and composition of the wastewater from the secondary wastewater treatment process should be analysed.

2) To elucidate performance of microbial consortia

It is important to elucidate the performance of microbial consortia. A microbial consortium is two or more microbial groups living symbiotically. Consortiums can be endosymbiotic or ectosymbiotic.

Due to the large variety of microbial consortia, some experiments should be done to test the efficiency of individual microbes and different consortia for wastewater treatment. Meanwhile, the analysis also can be supplemented with the help of a substantive literature review. Analysis will help to optimize the operational parameters for bioremediation of wastewater from the secondary treatment plant. The successful organism/s will be tested in a pilot plant using bioreactors.



3) To remove any remaining residue from the secondary treatment plant

After elucidating the performance of microbial consortia, appropriate microbial consortia should be selected and tested in experiments, to explore the operational parameters in the application. In order to certify that the microbial consortium can be applied to the treatment of large amounts of wastewater, an appropriate bioreactor should be designed for large scale treatment based on lab scale results, and then, the evaluation of the large scale treatment process should be done. During this research period, the cost involved in implementation will need to be calculated.

The result will indicate which design methods or guidelines for an appropriate bioreactor using microbial consortia can be applied to the current wastewater treatment plants.

4) To determine the quality of treated water

There is a uniform national standard for effluent from wastewater treatment plants in Viet Nam. The existing wastewater treatment plants just treat the wastewater and release it to the river, without the consideration of water recycling. However, treated water for domestic usage may be possible.

At this stage, water quality assessment of treated water with the set standard includes pH, COD, BOD, electrical conductivity and bacteriological tests, and decision on the supply of water for commercial or domestic purposes using the obtained data from water quality assessment can be done.

3. Methodology

As stated above, this research has four objectives;

(1) To identify effective micro-organisms available to treat the water generated from secondary water treatment plant

(2) To elucidate performance of microbial consortia

(3) To remove any remaining residue from the secondary treatment plant

(4) To determine the quality of the treated water

Specific research questions	Techniques of data collection	Source of data	Techniques of data analysis/ model development
1.1 Analysis of physical, chemical, and biological characteristics of water from secondary treatment process	Literature review and experimental observations	Primary data; secondary data	Colorimetric methods, titration, spectrophotometric techniques, statistical analysis
1.2 Identification, isolation and characterization of microbial consortia to be used for bioremediation	Molecular, physical, and chemical methods	Primary data	Serial dilutions, plate growth methods, molecular identification techniques (16S rDNA technology)
2.1Testing the efficiency of individual microbes and consortia for wastewater treatment	Literature review and experimental observations	Primary data and its validation with previous studies (secondary data)	Spectrophotometric techniques, statistical analysis

2.2 Optimization of operational parameters for bioremediation of wastewater from the secondary treatment plant.	Various experimental parameters will be tested for different bioremediation treatment parameters based on the results from objective 1.	Primary data	Establishment of microcosms to treat water using microbial consortia (eg: bench scale trickling filters), statistical analysis
2.3 The successful organism/s will be tested in a pilot plant using bioreactors	Software based experimental observations and statistical analysis	Primary data	Trickling filters (eg: pilot scale trickling filters) statistics
3.1 Design appropriate bioreactor for large scale based on lab scale results	Software based experimental observations and statistical analysis	Primary data	Statistics Eg.: large scale trickling filters
3.2 Evaluation of treatment process in large scale	Physical, biological, and chemical techniques	Primary data	Spectrophotometric techniques, statistics
3.3 Calculation of cost involved in implementation	Software based calculations with previously obtained data	Primary and secondary data	Instrument cost, researcher/s pay, consumables, stationery, rent etc.
4.1Water quality assessment of treated water with the set standards of pH, COD, BOD, electrical conductivity, and bacteriological test	Literature review and experimental observations	Primary and secondary data	Colorimetric methods, titration, spectrophotometric techniques
4.2 Decision on the supply of water for commercial or domestic purposes using the obtained data from water quality assessment	Primary and secondary data	Primary and secondary data	Based on results of complete experimental setup

4. Timeline

According to the plan, this research should be done within three years, including literature review for six months, data collection for 15 months, data analysis and model development for 18 months, policy recommendation for 6 months and writing up during all the research period. The specific timeline is shown in the following table.

Gantt chart showing the time line

Project compo nent	Time (e.g. Month)	3	6	9	12	15	18	21	24	27	30	33	36
Literature review													
Data collection													
Data analysis/ model development													
Policy recommendation													
Write up													

Note: Write up (Papers expected):

Literature review: Review paper

Paper 1: Isolation and characterization

Paper 2: Lab scale experimental findings

Paper 3: Large scale experimental findings

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