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RESEARCH ARTICLE OPEN ACCESS

Role of Algal Biosensors in Water Pollution Monitoring

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ABSTRACT
Today, water pollution is one of the major crises facing by the globe. Pollutants like organic and inorganic have very harmful effects on our ecosystem. At this stage, biosensors are early warning system to detect these pollutants from water stream at various concentrations. As microorganisms are very sensitive to any change in environment and these pollutants changes the conditions in water bodies, algal based sensors are adaptable solution for detection of pollutants in the water. Therefore, the present review study tried to compile the information related to algal biosensors available in the literature. This review paper discussed various types and functioning of the algal biosensor for detecting the pollutants/contaminants at early stages.
Keywords: Water pollution, biosensor, genetically modified biosensors; pesticide and heavy metal.

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I. INTRODUCTION

Water is nature's most precious and essential gift to mankind. It is the vital component for sustenance of life. Agriculture and Industries are two main pillars of Indian economy. Waste produced by agriculture and industrial sectors is mostly dumped in water. Usually, this waste has organic and inorganic pollutants. (https://www.ibef.org/industry/agriculture-india.com). Agricultural runoffs result in contamination of water bodies make them unsuitable for drinking purpose. Degradation of water quality leads to decrease the productivity of land and polluted soil and water through emission of pesticides, fertilizers, nutrients, salts, trace elements and so on (Rawat et al 2018). Industries are the huge source of water pollution, it produces pollutants that are extremely harmful to people and the environment. Mainly these pollutants are heavy metals extract, dyes and acid-base chemicals.
(https://www.water-pollution.org.uk/industrial-water-pollution/).

According to NITI Aayog 40% of Indians will have no access to drinking water by 2030. Water pollution causing a big problem in developing countries millions of people even not have safe drinking water (Shao et al 2002).

An important problem in emerging countries is water pollution due to industry and agricultural emissions, while in un-developed countries more than five hundred million people even don't have safe drinking water (Brayner et al., 2011). Mostly, water contaminants are including both inorganic like chemicals, heavy metals etc. and organic like insecticides, detergents, pesticides, volatile compounds etc. (Brayner et al., 2011). The purpose of wastewater treatment is basically to eliminate or reduce the level of pollutants so it can be considered safe for its anticipated end-use (Brayner et al., 2011). Presently, a number of conventional physicochemical analyses are using for water pollution monitoring, but these methods are complex and costly (Brayner et al., 2011). Hence, there is an urgent need of some monitoring tools which can even detect a very low concentration of contaminants in the water stream at early stage.

In order to conserve the water resource, algal biosensor can play a major role as they can detect toxic pollutants present in water. As the micro-algae is quite sensitive to its surrounding thus facilitates the easy detection of pollutants. They can detect toxic pollutants present in water. Biosensors exhibit a response very shortly and detection of pollutants at minimum concentration. Biosensors are usable for long time with highly efficient activity.

So, the main objective of biosensors is detection of pollutants, present scenario of pollution and prepare for the future. Algae play a vital role in the aquatic body as primary producer.

Being a primary producer, they produce oxygen and organic matter in the water body and purify the water (Campanella et al 2001). Micro and macro algae used for the assessment and monitoring of aquatic ecosystem because microorganisms are very sensitive to any change in environment and toxic materials which are responsible to cause change in the conditions of water bodies (Durrieu et al 2004). Although standard techniques which is highly accurate precise and sensitive to specific pollutants. Hence, algal strains are perfect for the fulfillment of the needs of biosensors for detection of pollutants.

Therefore, this present review paper is trying to compile all the available information in literature on algal biosensor their types and strains utilized for the formation of algal biosensor.

II. BIOSENSORS

"Biosensors or biological sensors are device made up of a transducer and bioreceptor which can identify analytes and turn that information into a measurable signal" (https://www.electronicshub.org/types-of-biosensors/). There are two parts of biosensors is bioreceptor and transducer (Brayner et al., 2011):

i. **Bioreceptor:** Bioreceptor may be comprised of any enzyme, antibody, nucleic acid, whole cell, tissue and microorganism.

ii. **Transducer:** Transducer is the other part of biosensor and having optical, electrochemical, thermal, mass-based, ion- sensitive and resistant. Selectivity and specificity depends on biological recognition system connected to suitable transducer (https://www.electronicshub.org/types-of-biosensors/).

Basic principle of biosensor is mainly involved three elements:

i. Biological recognition element

ii. Transducers detect and transduces signal from biological target

iii. Then transduction of signals from biological to electric signals (https://www.electronicshub.org/types-of-biosensors/).

III. NEED OF ALGAL BIOSENSOR

This technique is rapid and accurate for detection of pollutants at low level concentration in fluid body, water and air. Rapid, accurate and efficient technique is required for the issue of environmental safety. Bio-algal biosensors are based on micro algae and cyanobacteria (blue green algae). Algal biosensor detects herbicide, volatile organic compounds (VOCs), heavy metals etc. Algal-biosensors measure different metabolic activities of the organism. As toxic and hazardous substances create large effect on metabolic activities of the cell and this effect transferred into the form of signals. Main target of these sensors is pesticide, herbicide, and fungicide detection. For aquatic risk management and environmental monitoring algae is used in bio assays (Kashem et al., 2019). Alga is very sensitive and having high reproducibility therefore, it is used for removal of toxicity (Durrieu et al 2004). However, biosensors have been developed for assessment of water toxicity. On the basis of electrochemical reduction of oxygen and fluorescence of chlorophyll inhibit photosynthesis activity. Alternativity activity of algal protoplast and gravitaxis or phototaxis of algae is monitored electrochemically (Tatsuma et al 2009).

The main advantages of biosensors are that it is very selective to any type of pollutants e.g. the heavy metals inhibit the enzymes synthesis as inhibition of alkaline phosphatase and esterase and pesticide attack on PSII as chlorophyll fluorescence emitted from photosynthetic activity (Durrieu et al 2004).

IV. TYPES OF BIOSENSOR

Mainly there are two type of biosensor:

i. Natural– These algal strains occur in natural conditions. These microbes mostly function in living organism (*Chlorella vulgaris).* Natural algal biosensors are mostly working on the photosynthetic activity of algae. In these types of biosensors, the activity of photosynthesis in living cells influenced due to the presence of various pollutants. Some biosensors are based on the fluorescence of chlorophyll stored in chloroplasts. Algal biosensors currently use the chlorophyll fluorescence as the measurable signal. Chlorophyll fluorescence is used to quantify the herbicides that affect the photosynthesis at PSII for example triazines, atrazine (Durrieu et al 2004).

ii. Genetically modified- They are genetically modified gene of any microorganism. Artificial biosensors have so many advantages. Natural biosensors have certain limitations but to overcome these problems biotechnological modified strains of biosensors are used, work with high efficiency and easily detectable. According to Shao et al (2002) a freshwater cyanobacteria, *Synechocystis* sp. strain PCC6803, was genetically modified with the gene *lucvia luciferase* of firefly (a novel bio-luminescent alga) which is sensitive to a wide range of compounds like herbicides and other pollutants.

The main application of these biosensors is important for quick screening of water samples or determines toxicity of pollutants to harm the environment (Shao et al 2002). The biosensors could also help to indicate the type of pollutant and potential of pollutant to harm

Table1: Algal-biosensors used for detection of various pollutants

Algae	Pollutants	Reference
Chlorella vulgaris immobilization in alginate	Organic	Durrieu et al 2004
Chlorella vulgaris	VOCs	Durrieu et al 2004
Synechocystis sp. Strain PCC6803	Organic	Shao et al 2002
Dictyosphareiumchlorelloides	Organic	Durrieu et al 2004
Chlorella vulgaris immobilization in silica micro-columns	Inorganic	Durrieu et al 2004
T.pyriformis		
Chlorella vulgaris in between two platinum electrodes	Organic	Brayner et al 2011
Chlorella vulgaris immobilized in BSA	Inorganic	Durrieu et al 2004
Pseudokrichneriella		
Subcapitata	Inorganic	Durrieu et al 2004
*Dictyosphareiumchlorelloides*in sol gel silica matrix	Organic	Kashem et al, 2019
Synechococcus PCC7942 immobilized in PVA-SbQ	Inorganic	Durrieu et al 2004
Chlamydomonasreinhardtii	Inorganic/organic	Durrieu et al 2004
Synechococcus PCC7942		
Ananaenatorulosa immobilized on an oxygen electrode	Organic	Ferro et al 2012
	Inorganic	
	Inorganic	Durrieu et al 2004
	Organic	Durrieu et al 2004
		Durrieu et al 2004

V. WORKING OF ALGAL BIOSENSORS

Biosensor consists of a bioreceptor that sense biological element and transducer which determines the signals (biochemical) and converts into an optical or electrical signal. Biosensors facilitate fast, accurate rapid and low concentration screening of a number of compounds.

Depending on the type biological element used the response/signal varies. The signal is than amplified and filtered using signal processing unit (SPU) and the outcome of the SPU is an analog signal which is equal to the biological quantity measured (https://www.electronicshub.org/types-of-biosensors/).

Element (Biological in nature)

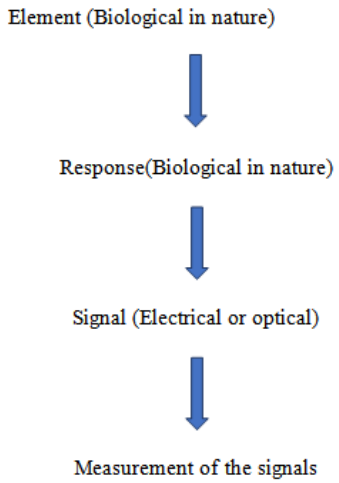

Fig.1: Flow diagram showing the working of algal biosensors

(Source: https://www.electronicshub.org/types-of-biosensors/).

However, specifically in algal biosensors, the fluorescence emitted by the photosynthetic activities of algae used to facilitate the detection of toxic substances. The equivalent signals are received with optical and conducto-metric transducers (hal-emse.ccsd.cnrs.f). This tool is designed to observe various simultaneous metabolic activities of immobilized algae (Durrieu et al 2006).

VI. CONCLUSION

This review paper focuses on the role of algae as biosensor for removal of pollutants at very low concentration. Biosensors are highly sensitive and reproducible. This method is more reliable and frequently usable as compare to other analytical techniques. The main advantage of biosensors is that it is very selective to any type of pollutants for example heavy metals inhibits the enzymes synthesis as inhibition of alkaline phosphatase and esterase and pesticide attack on PSII as chlorophyll fluorescence emitted from photosynthetic activity. Genetically modified biosensors are proved to be more simple, reliable, fast, precise. Novel bio-luminescent algal strains are profound to a wide variety of organic and inorganic compounds like herbicides and other pollutants. Both types of biosensors are effective but have some limitation, because in the field condition different factors produce multiple effects on their activity. Further studies and research work is required to form an effective biosensor.

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