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Evaluation of Microorganisms that Break Down Phenol Toxicity Remediation in Aquatic Environments: Separation, Identification and Potential Application

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Abstract

The most precious natural resource on Earth is water. Water makes up 71% of the earth's surface, and life as we know it would not exist otherwise. Pollution of the valuable water resources, however, is a prevalent and complex issue that the modern society is now dealing with. Man-made (synthetic) organic compound pollution of the environment has grown to be a serious issue and is becoming worse every day as a result of growing urbanisation and industry (Ghisalba, 1983). As a result, several hazardous chemicals are contaminating natural water bodies more often. Since freshwater supplies are being depleted quickly and some are being polluted by different contaminants, the availability of clean and safe drinking water is becoming a serious problem. Both surface and ground water have been severely contaminated by industrial and residential activities (Singletary, 1997). All industrial and household wastewater eventually ends up in water supplies, either directly or indirectly through other damaged habitats like soil. The causes of water contamination are many. The main sources are industrial wastes dumped into aquatic bodies and municipal sewages. Cities in India lack the necessary infrastructure to properly handle their waste water. Merely 10% of the wastewater produced from many sources undergoes treatment; the remaining untreated sewage is released into water bodies, so harming rivers and other bodies of water. These extremely polluted discharges contain bacteria that cause sickness as well as extremely hazardous pollutants. Since agricultural runoff includes fertilisers and pesticides, it is still another significant source of river pollution. Sewage and serious environmental contaminants are found in wastewater from residential or commercial discharges. Pollutants entering the water may be biodegradable, non-biodegradable, poisonous, or non-toxic. It might be radioactive, chemical, or biological in origin. Many of our natural water sources are irreversibly harmed as a result of the widespread environmental pollution caused by toxic wastes that are being discharged into the environment (Ollis, 2000). When exposed to the environment over an extended period of time, hazardous effluents from various industrial discharges can result in diseases such as cancer, mutagenic alterations, neurological problems, malformations in urban children, and diseases in fish, among other effects (Govindarajalu, 2003). Reducing the amount of these environmentally harmful activities is necessary for a sustainable quality of life. While conservation and better resource utilisation have the most impact on the planet's sustainability, new strategies such as enhanced treatment technology and waste utilisation have been created and used on a regular basis to maintain environmental quality. The dissolved oxygen concentration of the water falls below the necessary threshold due to the degradation of these contaminants by microorganisms found in aquatic habitats, which seriously harms aquatic life.

KEYWORD: Phenol, biodegradable, non-biodegradable, poisonous, or non-toxic, waste water

INTRODUCTION

In India, water pollution is a severe and expanding issue. According to the World Water Development Report (2012), 80 percent of household garbage and 70 percent of industrial waste are dumped into rivers in underdeveloped nations, severely contaminating these priceless resources. There are several health concerns associated with direct exposure to untreated wastes, including infections, chronic diseases, problems with reproduction, and even early death of children living along the banks of contaminated rivers. Even at significant distances from the site of pollution, there remains a danger to health from indirect exposure to harmful chemicals through polluted food chains and groundwater (World Health Organisation 2008a and 2008b). The US Environmental Protection Agency (EPA) has established water quality guidelines for 129 particular priority chemicals, including phenol (Singh et al. 2013; Babich and Davis 1981). According to the Clean Water Act Amendments of 1977, it is harmful.

Because phenol is widely utilised as an intermediate in industrial processes to produce commodities, its production and usage are growing daily. Due to phenol's well-known harmful effects on the environment, a great deal of study has been done globally to prevent and clean up phenol pollution. The World Health Organisation (WHO) has set a maximum permitted concentration of 1 mg/L of phenol as the amount that can be present in drinking water. Phenol gives out a characteristic scent when it is chlorinated at a concentration of 5 mg/L (Saravanan et al., 2008). It is one among the most pervasive environmental contaminants that may be detected in industrial and wastewater effluents. Asia is predicted to produce 53% of the world's phenol output, which is predicted to reach 14 million tonnes annually by the end of 2020 (ICIS, 2018). Deepak Phenolic Limited (DPL) alone produces over 200,000 tonnes of phenol annually in Dahej, Gujarat (ICIS, 2018). Therefore, in order to lessen the amount of excess phenol-containing industrial effluent that ends up in natural water bodies and land, it is imperative that this waste be dealt with adequately. Water and soils are seriously at danger due to phenol's presence in a variety of environmental samples. According to Gianfreda et al. (2006), phenol is resistant to degradation and hence should be handled carefully before being released into the environment (Basak et al., 2013, Lobo et al., 2013). Complete mineralization of the compound is achieved by the cost-effective biological treatment that lowers the phenol level in different industrial effluents (Nuhoglu & Yalcin, 2005). In the presence of high phenol concentrations and under various reaction circumstances, non-specific biological treatment methods for industrial effluents containing phenol, such as activated sludge systems, are frequently inefficient (Boczkaj et al., 2016).

LITERATURE REVIEW

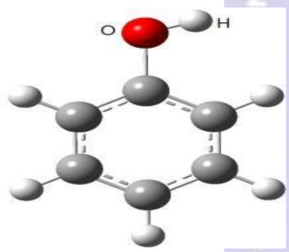
Environmental Pollution

One of the unintended consequences of the modern industrial civilization is environmental contamination. Industrial wastes contain poisonous, cancer-causing, and mutagenic qualities (Busca). et al., 2008) and one of the trickiest issues is how to properly manage them. Towns Moreover, municipalities produce enormous amounts of garbage every day, and treating such wastes is a crucial component of any contemporary city planning. Most of these contaminants are found in organic the makeup and existence of these organic substances, whether they come from home or commercial sources, there is a significant public health issue with the environment. both terrestrial and aquatic Lakes, rivers, and oceans are becoming polluted with many harmful substances including formaldehyde, phenol, ammonia, cyanides, thiocyanate, acrylonitrile and aceto-nitrile, mercury, and others. Thirty monoaromatic compounds are included in the EPA's priority pollutant list, and eleven of these compounds are in the top 100 dangerous substances on the Agency's toxic substances and disease registry priority list. Among the common pollutants are monoaromatic hydrocarbons, which include phenol, toluene, and benzene. Of these, phenol and its derivatives are regarded as priority pollutants. One to several hundred mg/L can be found in the quantities of phenol or phenolic compounds (Moussavi et al., 2009). Long-term environmental persistence and accumulation of phenolic chemicals allow them to accumulate and have harmful effects on living things (Bruce et al., 1987). When phenolic effluents are released into aquatic environments, the native biota is negatively impacted.

Decomposition by biosynthesis

Biodegradation is the process by which complex chemicals are broken down into simpler forms in the environment that may be readily incorporated into the regular biogeochemical cycles by living creatures, most notably by microorganisms. This technique is generally acknowledged as a more cost-effective and environmentally friendly treatment technology than alternatives. It is also largely acknowledged to be efficient. By lowering the concentration of the pollutant (bioattenuation), the process of bioremediation happens spontaneously. But this is a sluggish process that frequently needs to be accelerated by a nutrition supply (biostimulation). Bioaugmentation is the addition of bacterial inoculums with desirable enzymatic capabilities when the environment to be treated lacks the necessary microorganisms. But because of the potential consequences for the ecosystem, its application must also be done with caution, particularly when employing allochthonous (i.e., organisms from a different habitat) species. Autochthonous bioaugmentation, using well-characterized indigenous microorganisms, has been proposed and is considered a promising option to remediate hydrocarbon-contaminated sites and to reduce contamination risks (Wu et al., 2013). The isolation of pure cultures or consortia of microorganisms from the polluted environments is important before providing an inoculum for bioaugmentation. Bioremediation, which involves the use of microbes to detoxify and degrade environmental contaminants, is considered as an effective biotechnological approach to clean up a polluted environment. Bioremediation has several advantages over the conventional chemical and physical treatment technologies, especially for diluted and widely spread contaminants. In situ treatment is one of the most attractive advantages of this technology. The term ‗in situ' is a Latin word which means ―in its original place‖. In situ bioremediation enables us to remediate a contaminated site without transportation of contaminants and with minimum site disruption (Iwamoto & Nasu, 2001). Bioremediation is an effective tool for cleaning up various toxicants because it is easy to maintain, applicable over large areas, cost-effective and leads to complete mineralization of the contaminant. However, one of the difficulties in developing bioremediation process lies in achieving better results in the field as in the laboratory(Juhasz & Naidu, 2000).

The compound has limited solubility in water (6.7 g/100 ml) and is soluble in most organic solvents. The melting point of 43 °C is lowered by the addition of water to the extent that a 90 % mixture of phenol in water (phenolum liquefactum) is liquid at room temperature. Chemically, the compound is a weak acid. The pH of aqueous solution is about 6.0. It reacts readily with oxidizing agents.Phenolis mainly recovered from coal tar.



Phenol

The phenol ring structure is present in many organic compounds and such compounds are commonly called phenolic compounds. Phenolic compounds are commonly classified based on number of carbon or phenyl group in the structure (Harborne, 1967, Harborne, 1980) and are given in Table

Common phenolic compounds and their classification

No. of carbon atoms	Number of phenolic units	Class	Example
6	1	Simple phenols	Catechol
6	1	Benzoquinones	Hydroquinone
7	1	Phenolic acids	Salicylic acid
8	1	Acetophenones	Tyrosol
9	1	Hydroxycinnamicacids, Chromones	Caffeic acids, Eugeni
10	1	Naphthoquinones	Juglone, Plumbagin
13	2	Xanthonoids	Mangiferin
14	2	Stilbenoids, Anthraquinones	Resveratrol, Emodin

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No. of carbon atoms	Number of phenolic units	Class	Example
15	2	Chalconoids, Flavonoids, Isoflavonoids, Neoflavonoids	Amentoflavone Quercetin, cyanidin, Genistein
16	2	Halogenated algal phenolic compounds	Kaviol A, colpol
18	2	Lignans, Neolignans	Pinoresinol, Eusiderin
30	4	Biflavonoid	Amentoflavone
many	n>12	Lignin, Polyphenols	Tannic Aid

Phenol: Among the most prevalent pollutants that should be taken seriously

Major xenobiotics, phenol and its substituent phenolic compounds, are frequently found in the effluents released by industries such paper and pulp, steel, oil refineries, fertilisers, textiles, petrol and coke, etc. One of the most dangerous pollutants is phenol, which is poisonous to both humans and aquatic life. Longer environmental half-lives allow phenolic chemicals to continue their harmful impacts on living things (Bruce et al., 1987). Even at low quantities, phenol and phenolic compounds are regarded as one of the most dangerous pollutants. If phenol is consumed, absorbed via the skin, or inhaled, it can be lethal. It may quickly permeate the skin and lead to serious health issues; intake of even 1 g of phenol has been shown to be fatal to humans (Al-Khalid & El-Naas, 2012). Because of its harmful effects on living things, the release of phenol and phenolic compounds into aquatic environments is always undesirable. Whenever possible, it is preferable to eliminate harmful phenolic compounds from wastewater before to release in order to reduce harmful consequences.

FISH ARE HOUSED WITH BACTERIA IN A MESOCOSM SYSTEM DURING THE BACTERIAL BIODEGRADATION OF PHENOL.

Mesocosms are manually constructed outdoor enclosures with volumes ranging from 1 to over 10,000 L. For a specific goal and in real-world field settings, they are utilised to investigate the complex exposure dynamics of investigated or experimental organisms (Culp and Baird, 2006). Mesocosm studies involve moving laboratory research into a real-world setting where some crucial variables (such as the species involved and the contaminant concentration) can be regulated and the process takes place in conditions similar to those found in nature (such as diel temperature cycles and naturally occurring pond water). Creating exposure scenarios that were more realistic than controlled laboratory experiments was the aim of these investigations. The bioremediation process is a sustainable method because microorganisms possess the metabolic capacity to convert organic contaminants created by humans into more readily digested forms. An ecotoxicological experiment involving two fish species shown a significant reduction in the toxicity of phenol following treatment. Thus, our research showed that the use of a consortium of hyper-phenol-tolerant bacteria, which lowers the phenol load in both the microcosm and mesocosm systems, might effectively be employed to treat phenol-contaminated pond water for fish farming.

CONCLUSION

The idea of employing microorganisms to lessen pollution loads is mostly still explored through in situ experiments conducted in controlled laboratory environments. Many times, phenol was treated as a pollutant in a specially built bioreactor under a controlled system, but the effectiveness of any biodegradation process in its natural state or on the site of a polluted area lowers the process's cost while also increasing its applicability and usability. Fish survivorship in phenol-intoxicated systems is increased when consortia of bacteria produced from the four hypertolerant isolates in equal proportion are introduced in the mesocosm setup. The study demonstrates the strains' value for recovering phenol-contaminated water in an economical and environmentally acceptable manner while also making the polluted system suitable for fish development.

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