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Research papers

Academic Year 2018 – 2019

S.No.	Title of paper	Name of the author/s	Department of the teacher	Name of journal
1.	Biogreen remediation of chromium-contaminated soil using Pseudomonas sp. (RPT) and neem (Azadirachta indica) oil cake	M. Govarthanan, T. Selvankumar, R. Mythili, P. Srinivasan	Biotechnology	International Journal of Environmental Science and Technology
2.	Effect of blue light on growth and exopolysaccharides production in phototrophic Rhodobacter sp. BT18 isolated from brackish water	T. Selvankumar, R.Mythili, P. Srinivasan	Biotechnology	International Journal of Biological Macromolecules
3.	Phytosynthesis of silver nanoparticles using Mangifera indica flower extract as bioreductant and their broad-spectrum antibacterial activity.	P. Srinivasan, T. Selvankumar	Biotechnology	Bioorganic Chemistry
4.	In-vitro bio-mineralization of arsenic and lead from aqueous solution and soil by wood rot fungus, Trichoderma sp.	R. Mythili, T. Selvankumar, P. Srinivasan,	Biotechnology	Ecotoxicology and Environmental Safety
5.	Manipulating the Magnetization focal patterns using Complex Phase Filters	K. Prabakaran	Physics	Optica Applicata

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ORIGINAL PAPER

Biogreen remediation of chromium-contaminated soil using *Pseudomonas* sp. (RPT) and neem (*Azadirachta indica*) oil cake

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Abstract

The prospective of indigenous *Pseudomonas* sp. (RPT) and neem oil cake for enhanced removal of chromium (Cr) from contaminated soil microcosm was explored in this study. The bacteria were isolated from Cr-contaminated soil and identified as *Pseudomonas* sp. based on partial 16S rDNA sequencing. The isolate RPT showed high Cr(VI) tolerance (1000 mg/l) and removal rate (64.4%) in batch experiments. Transmission electron microscopy observation showed that the isolate effectively precipitated the Cr both intra- and extracellularly. Microcosm studies revealed that neem oil cake amendment (7.5% w/v) enhanced Cr(VI) removal (82%) from contaminated soil. Furthermore, soil enzyme activities were increased in the biostimulated soil. The obtained results indicated that the application of neem oil cake along with indigenous Cr(VI)-resistant bacteria could inspire the bioremediation of Cr(VI)-contaminated soil field scale.

Keywords Chromium · Neem oil cake · *Pseudomonas* sp. · Remediation · Soil

Introduction

Metals originating from metallurgical industries, mines and/or ores are a serious environmental issue as it contaminates both soil and water. The continuous accumulation of metals in the soil and water streams causes biological disorders in humans and other living organisms (Govarthanan et al. 2018; Rieger et al. 2018). With the various metals that contaminate the ecosystem, chromium (Cr) has a special place because of its wide applications in various industries.

Chromium sulfate is the commonly used tanning agent in tanneries. Ranipet (Vellore, Tamil Nadu, India) is well known for tanneries. It is reported that nearly 240 tanneries are located in this area and that they release approximately 220,000 tons of solid waste into the soil (Sundaramoorthy et al. 2016). Under certain circumstances, the trivalent chromium salts (Cr(III)) present in the solid wastes get oxidized into hexavalent chromium salts (Cr(VI)), a highly toxic form. Thus, soil and surface water system in this area are heavily polluted with Cr(III) and Cr(VI). However, only limited attempts have been made to remove and/or reduce Cr(VI) from the contaminated surface soils. Therefore, there is an immediate need to develop simple and eco-friendly methods for the removal of Cr from contaminated soils.

Recently, various technologies (physicochemical methods) have been developed with the goal of reducing Cr pollution in the contaminated ecosystem. Although physicochemical methods have been applied in practice, these methods carry several disadvantages (Ali et al. 2011; Ok et al. 2011; Saravanan et al. 2013a, b, 2015; Robati et al. 2016). Bioremediation is considered as a simple, inexpensive and eco-friendly technology that uses biotic communities for the remediation of contaminated soils. Microorganisms are primarily used, in bioremediation, to degrade or

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Effect of blue light on growth and exopolysaccharides production in phototrophic *Rhodobacter* sp. BT18 isolated from brackish water

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ABSTRACT

Rhodobacter sp. BT18, a phototrophic salt-resistant bacterium, was isolated from brackish water and screened for the production of exopolysaccharides (EPS). The effect of different light sources on the growth of *Rhodobacter* sp. BT18 was investigated. The effect on the growth order was found to be blue > white > green > red > yellow > dark. Based on Box-Behnken design, the studied variables (pH 7.0, 35 °C, and 30% of sucrose concentration under 60 h of incubation with blue light illumination) were found to be ideal for the maximum production of EPS (582.5 mg/L). Scanning electron microscopy images revealed the porous nature of EPS. Fourier transform spectroscopy and X-ray diffraction were applied to study the functional groups and the crystalline nature of the EPS, respectively. The emulsification index of the EPS was >75% and the maximum flocculating activity was about 75.4% at 30 mg/L concentration of EPS. In addition, EPS showed effective arsenic (64%) and lead (51%) chelating activities in liquid solutions. The multiple environmental applications of the EPS produced by *Rhodobacter* sp. BT18 make it be a promising alternative for emulsification, flocculation and metal removal in various industries.

1. Introduction

Bacterial exopolysaccharides (EPS) are extracellular biopolymers that are linear and/or branched sugar molecules composed of heterogeneous monomers coupled with glycosidic bonds [1]. Due to their viscosity, high emulsification, gelling nature [2], they find extensive applications in food, pharmaceutical and agricultural areas [3,4]. Owing to the wide range of industrial applications and unique structural properties, bacterial EPS are gaining increased attention and are gradually becoming economically competitive with synthetic and other biopolymers produced by plants and algae [5–7]. Bacterial EPS have been found to be highly water soluble, stable, and rheological. They have emulsifying properties and are effective across a wide range of pH and temperature [8].

Several studies have reported the production of EPS by bacteria including *Pseudomonas* sp. [5], *Bacillus* sp. [9,10], *Rhodothermus marinus* [11], *Leuconostoc mesenteroides* [12], and *Halomonas* sp. [1,4]. However, Bacteria from extreme environments have gained increased attention due to their special metabolic pathways and defensive mechanisms that enable them to withstand the harsh conditions [5]. Numerous studies have reported the EPS production by bacteria isolated from a variety of soil and water matrixes; however, there is no report on EPS produced by bacteria from brackish water environment, a buffering zone of sea and inland water.

Rhodobacter sp. is a gram-negative, phototrophic non-sulphur purple bacterium widely distributed across seas, rivers and lakes [13]. It grows under both anaerobic and aerobic conditions with several metabolic pathways depending on the growth environment [14]. Several studies have reported the environmental applications of *Rhodobacter* sp. including bioremediation of heavy metals and polyaromatic hydrocarbons [15–17]. It has been reported that the growth of the phototrophic bacterium is greatly influenced by several physico-chemical parameters, such as light source, light intensity, temperature, pH, and available carbon sources present in the cultivation medium. Among all other parameters, light source greatly affects the cell growth, and metabolic pathways of the phototrophic bacterium [18]. Therefore, the present study investigated the effect of different light on the growth and metabolic activity of the phototrophic bacterium. From this perspective, this study was designed (i) to isolate and identify the phototrophic *Rhodobacter* sp. from brackish water, (ii) to evaluate the influence of different light sources on the growth of *Rhodobacter* sp., (iii) to screen for EPS production, and analyze the effect of different sources of light and carbon, pH, and temperature of the growth medium on EPS production (iv) and to assess the flocculating, emulsifying and the metal chelation activity of the *Rhodobacter* sp. BT18 EPS.

2. Materials and methods

2.1. Isolation of EPS-producing phototrophic bacteria

Brackish water samples (~1 to 2 m depth) was collected from Pichavaram mangrove (11°23′–11°30′ and 79°45′–79°50′), Tamil

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Short communication

Phytosynthesis of silver nanoparticles using *Mangifera indica* flower extract as bioreductant and their broad-spectrum antibacterial activity

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ABSTRACT

The present study focused on the evaluation of antibacterial property of silver nanoparticles (AgNPs) synthesized using mango flower extract. The morphology of the synthesized AgNPs was observed under transmission electron microscopy and the particles have shown spherical shape in the range of 10–20 nm. X-ray powder diffraction analysis confirmed the crystalline nature of the AgNPs. The atomic percentage of the Ag element in the nanoparticles was about 7.58% which is greater than the other elements present in the sample. The AgNPs showed extensive lethal effect on both Gram-positive (*Staphylococcus* sp.) and Gram-negative (*Klebsiella* sp., *Pantoea agglomerans*, and *Rahnella* sp.) bacteria. The extensive lethal effect of AgNPs against clinically important pathogens demonstrated that the mango flower mediated AgNPs could be applied as potential antibacterial agent to control the bacterial population in the respective industries.

1. Introduction

Bacterial contaminations remain as a one of the most severe issues in medical devices, water treatment and food industries [1]. Both Gram-positive and Gram-negative bacteria are common contaminants and cause diseases in human beings [2,3]. Several antibacterial agents are available in the market to control bacterial contaminations in various products. However, these available antibacterial agents have numerous drawbacks such as, reduced solubility, high cost, toxicity and side effects [4]. Thus, there is much interest to investigate safe and effective antibacterial compounds [5,6]. Currently, in several products, such as in disinfectants, metal nanoparticles are used as the active substance. Silver nanoparticles have proved their efficiency against pathogenic bacteria [7]. Silver nanoparticles (AgNPs) synthesis has gained much attention because they potentially offer a solution to overcome bacterial contaminations and/or infections in an effective and safe approach.

Several physico-chemical routes, including electro-chemical [8], photochemical [9], and radiation methods [10] are commonly used to produce AgNPs. These methods, however, have disadvantages due to environmental contamination or toxic residues in the nanoparticles [11]. Therefore, new environmentally friendly techniques, which use biological organisms to mediate the nanoparticle synthesis, are still searched.

Efficient biological substrates used in the production of AgNPs are various, for instance, plant extracts [12,13], microorganisms [14], algae [15], panchakavya [16], oilcake [17], vegetable waste [18], seaweed [19], enzymes [20], and metabolites of arthropods [21]. It has been generally suggested that plant based materials are promising substrates for the AgNPs synthesis because the process is simple to scale up [22].

Mango (*Mangifera indica* L.) is an important tropical and sub-tropical crop belonging to the *Anacardiaceae* family [23,24]. The leaves of this native South-Asian species have various properties, including antidiabetic, antimicrobial and anti-inflammatory activities [25]. AgNPs have been successfully synthesized using mango peel [26] and leaves [27]. Mango flowers have not been reported for their efficiency of AgNPs synthesis and its broad-spectrum antibacterial activity. Hence, the study aimed (i) to produce AgNPs using a mango flower extract, (ii) to characterize the biosynthesized AgNPs using various spectroscopic techniques, and (iii) to measure their antibacterial property.

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In-vitro bio-mineralization of arsenic and lead from aqueous solution and soil by wood rot fungus, *Trichoderma* sp.

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ABSTRACT

In the present study, we investigated the role of calcite, i.e., microbiologically-induced precipitate by ureolytic *Trichoderma* sp. MG, in remediation of soils contaminated with arsenic (As) and lead (Pb). The fungus tolerates high concentrations of As (500 mg/L) and Pb (650 mg/L). The effects of three factors, i.e., urea concentration, $CaCl_2$ concentration and pH, on urease production and bio-mineralization of As and Pb were investigated using Box-Behnken design. The maximum urease production (920 U/mL) and metal removal efficiency (68% and 59% for Pb and AS, respectively) were observed in the medium containing urea of 300 mM and $CaCl_2$ of 75 mM at pH 9.0. Fourier transform infrared spectroscopy result revealed the formation of metal carbonates by the isolate MG. Sequential extraction of metals revealed that the carbonate fractions of As and Pb were increased to 46.4% and 42.4% in bioremediated soil, whereas in control they were 35.5% and 32.5%, respectively. The X-ray powder diffraction result further confirmed the role of calcite precipitate in bioremediation of As- and Pb-contaminated soils. The results points out that the microbiologically-induced calcite precipitation is a feasible, eco-friendly technology for the bioremediation of As- and Pb-contaminated sites.

1. Introduction

Arsenic (As) and lead (Pb) are well-known metals, primarily produced by mining, metal manufacturers, and human activities including modern industrial operations, and agricultural practices (Donahoe et al., 2004; Wang and Mulligan, 2006). The soil and/or water containing As and Pb pose(s) a serious threat to both the ecosystem and human health because of their high toxicity and difficulties in treatment (Hseu et al., 2010). The toxicity of the metals is associated with many kinds of human diseases including malfunctions of liver, heart, central nervous system, and kidney, skin and lung tumours, and cardiovascular disease (Dopp et al., 2004, 2010). Hence, a technology to efficiently remove As and Pb from contaminated soil and water has attracted increased attention worldwide.

The physico-chemical practices commonly applied for removal of As and Pb are ion exchange, chemical precipitation, electrochemical treatment, and reverse osmosis (Zhang et al., 2017). However, the applicability of these methods is limited because of their high cost, time demand and potential generation of secondary wastes (Cui et al., 2017). Recently, biological remediation of As and Pb is considered as a promising alternative due to its environmental friendliness and cost effectiveness (Govarthanan et al., 2010; Selvankumar et al., 2017). It has been well established that microorganisms can remediate As and Pb in soils through different routes such as intra and/or extra-cellular accumulation (Brookshaw et al., 2012), biosorption (Azarpira and Mahdavi, 2016; Balarak et al., 2016; Bazrafshan et al., 2017), bio-mineralization (Govarthanan et al., 2010), and chelation by producing organic acids (Gadd et al., 2012). However, the effectiveness of bioremediation of As and Pb varies depending on microbial sensitivity to soil redox potentials and/or valence state of metals (Qian et al., 2017).

Microbiologically-induced calcite precipitation (MICP) is a widely known in-situ bioremediation method, where metal-resistant microbes immobilize toxic metals in the form of minerals (Zhu and Dittrich, 2016). Recent progress in the science of MICP in bio-geological formations has shaped the interest of bioremediation researchers worldwide (Dhami et al., 2017). The precipitation of target metal compounds with calcium carbonate and its dominant derivatives (i.e., calcites) is mediated by a variety of bacteria, fungi, algae, and protista, thus, this mechanism is preferably defined as bio-mineralization and/or MICP (Gadd, 2010; Qian et al., 2015). Among the microorganisms, fungi have

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Manipulating the magnetization focal patterns using complex phase filters

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Based on vector diffraction theory and inverse Faraday effect, the light induced magnetization distribution of a tightly focused azimuthally polarized Bessel–Gauss beam superimposed with a helical phase and modulated by an optimized multi belt complex phase filter (MBCPF) is analyzed numerically. It is noted that by adjusting the radii of different rings of the complex phase filter, one can achieve many novel magnetization focal distributions, such as sub-wavelength scale (0.29λ) and super-long (71λ) pure longitudinal magnetic probe and magnetization chain composed of nine, six and four magnetic spots of sub-wavelength scale. The authors expect that these results pave the path for fabricating magnetic lattices for spin wave operation, multiple atoms or magnetic particle trapping and transportation, confocal and magnetic resonance microscopy, as well as multilayer ultrahigh density magnetic storage.

Keywords: inverse Faraday effect, high NA lens, multi belt complex phase filter, azimuthally polarized Bessel–Gauss beam.

1. Introduction

In the past two decades, controlling the magnetic state of a medium with the help of femtosecond laser pulses is an emerging and rapidly developing research area in the field of modern magnetism. Recent research has shown that it is possible to realize deterministic and controllable switching of magnetic orders by ultrafast light pulses [1–7]. Excitation of ultrafast magnetic oscillations through non-thermal optical processes has