Water Management

Development of an Effective Industrial Effluent Treatment System for Irrigation Purposes

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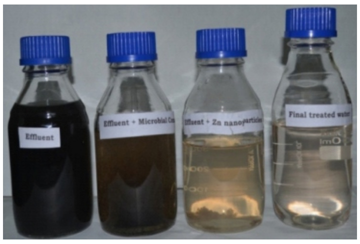

Effluent waste water successively treated using three-stage treatment system

ABSTRACT

Industrial waste water presents significant challenge as regards its treatment and reuse for irrigation in terms of qualifying parameters like biological and chemical oxygen demands, respectively (BOD and COD). In order to make such effluent reusable for irrigation purpose, an efficient treatment system has been successfully designed, developed, tested, validated and deployed. Moreover this system offers a definitive value addition in terms of an enhanced nutrient content in the treated effluent. In particular, the system is capable of complete removal of colour, odour and impurities from the effluent. Besides, the BOD and COD levels were reduced to the extent of more than 94% within a week thereby making the effluent suitable reusable for agriculture purposes.

KEYWORDS: Industrial effluent treatment, Filtration system, Microbial treatment, Plant growth, Zinc nitrate nanoparticle

Introduction

Industrial effluent treatment has gained global significance and became a high priority as well as an incrementally challenging task of recent times. This is attributed to the relentless advances in industries fueled by the exponential population growth which have in consequence contributed to the enormous rise in effluent volume. Different technologies and/or methods are being employed to manage this mammoth effluent generated all over the globe according to Shah [1]. Generally, the effluents are sent to Common Effluent Treatment Plants (CETP) for treatment. This increases the process cost, transportation overheads and time of treatment. In order to address these issues and achieve decentralised waste management an in-situ treatment of waste water is desired which is quite pertinent to small industries. Such in-situ treatment plants will be the key step in the cost-effective management of the huge quantity of effluent. Besides, re-purposing the industrial effluent through bio-remediation and its reuse for different applications has also emerged as an attractive research avenue of particular significance considering the ever-depleting water resources which in the long term are anticipated to compromise the sustainability of industrial growth as well as general societal wellbeing as per Pandey and Jain [2]. Utilization of heavy metal resistant bacteria from industrial waste water is extensively practiced in the bio-remediation studies as they can withstand the highly polluted environment and simultaneously detoxify the effluent. Therefore, the selection of suitable bacterial consortium having ability to survive in the highly polluted environment, tolerate the high levels of heavy metal concentrations and simultaneously degrade the toxic components is very much essential. Based on these aspects, a novel and improved integrated system has been developed and deployed. This system has brought a major reduction in the cost involved in transporting the water through pipes to and fro the CETP site. Besides, through the insightful use of zinc nitrate nanoparticles, it has also achieved the definitive value addition of the treated water in terms its nutrient enrichment namely zinc and nitrate content. The subsequent utilization of this nutrient enriched treated water has been fruitfully manifested for the healthy growth of plants.

Materials and Methods

Sample Collection from different Industrial Areas

Industrial effluent samples were collected from different industrial areas located in Maharashtra. All the standard procedures were followed during the sampling as well as analysis purpose. These samples were analyzed periodically for standard water quality parameters including pH, temperature, conductivity, total dissolved solids, TDS, total suspended solids (TSS), BOD, COD, alkalinity, chlorides, hardness and heavy metal content as reported by Kale and Bandela [3].

Primary Microbial Treatment

For bio-remediation of the waste water, selection of effective microbial consortium is a prerequisite. Effective bacteria were isolated from the same industrial effluent (*in situ*) and used for laboratory as well as field study. These bacteria were characterized for their ability to improve the water quality parameters as well as for their tolerance to different heavy metals and subsequently used as consortia for microbial treatment of the effluent.

Development of Filtration System

Filtration is an integral part of any effluent treatment

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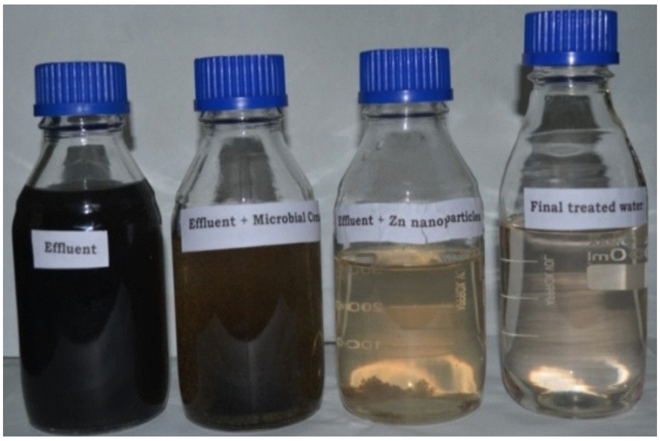

Fig.1: Effluent waste water treated successively using three-stage treatment system.

Fig.2: Pilot scale facility installed at BARC Training School Building, Anushaktinagar, Mumbai.

system. Conventional filtration systems are based on either sand or charcoal. In the present study, an improvised filtration system has been developed which comprises sand, charcoal, rice husk ash (waste product of rice processing industry) and resins (both cation and anion 1:1). All these materials were available locally and used for experimental purpose.

Secondary Treatment of Zinc Nitrate Nano Particles and Nanoparticle Characterization

Use of nanoparticles for water treatment has assumed a critical significance due to their reactivity and ability to reduce different pollutants. During the present study, zinc nitrate (zerovalent form @ 25 ppm) was used as a secondary treatment agent.

Pilot Study of Effluent Treatment Process

After benchmarking all the process parameters at laboratory scale, the system was successfully scaled up to treat 100 litre effluent per day under field condition. This system has been deployed (using plastic drums and columns made from PVC pipes) at Training School Complex, Anushaktinagar, Mumbai. At the beginning, microbial treatment of industrial effluent was done by inoculation with consortia comprising 05 bacteria each @ $1x10^6$ cells/ml in a plastic drum and subsequently aerated for 4 days. At the end of first stage, 90% water was transferred to next filtration stage with flow rate of 10 lit/h (in view of holding 10% microbial consortia for second cycle). Filtered water was collected in the plastic tank used for secondary treatment by nanoparticle solution (25 ppm) for 3 days. Post treated water after passing through muslin cloth was collected and tested for its BOD and COD level and used subsequently for irrigation purpose.

Effect of Post Treated Water on Growth of Crop Plants

Post treated water was tested in pot and microplots using Munbean and Spinach as test crop grown in duplicate. Both these plants were observed for their growth after treating with normal water (control) and treated one (post treated effluent water).

Results and Discussion

Sample Collection, Processing and Laboratory Studies on Effluent Treatment System

Based on the maximum threshold limit, colony characterization and growth behaviour, 05 bacteria were selected for microbial treatment. These bacteria include *Providencia stuartii, Klebsiella pneumonia, Alcaligenes spp., Citrobacter spp., Pseudomonas aeruginosa* as reported by Kale *et al* [4]. These bacteria survived in both acidic and basic pH conditions with optimum pH 7 and temperature 37°C, and also in salt concentration up to 10%. All the bacteria were found to secrete important enzymes like catalase, cellulose and amylase. These bacteria were mixed together to form consortium and used for treatment of effluent. After 3-4 days of microbial treatment, effluent was passed through filtration system followed by incubation with zinc nitrate nanoparticles which helped in further reduction of most of the water quality parameters. At last stage the effluent turned completely colourless (Fig.1) and all the water quality parameters were reduced to the levels as prescribed by regulatory agencies as per CPHEEO [5].

Pilot Scale Study on Effluent Treatment System Under Field Conditions

The industrial effluent brought from different industrial areas was tested in pilot plant of 100 L capacity per day (Fig. 2). All the water quality parameters were checked during entire experimental period. The effluent turned colourless and having all the water quality parameters well below the prescribed limits as set by pollution Control boards as per CPHEEO [5].

The developed system has successfully removed more than 94% COD, TDS and chlorides to acceptable limit.

Effect of Post Treated Water on the Growth of Crop Plants

Post-treated water was used as irrigation to Mung bean and Spinach plants grown in pots and micro plots. The treated water was found to be equally effective for growth of both the plants without any adverse effect on their growth (Fig. 3).

Industrial effluent treatment technologies are as old as the industries itself and are widely used by industries for treating effluent. CETP offers common platform for such technologies and thus widely accepted approach amongst all. In spite of availability of many technologies for treatment of effluent, there are incidences of not following proper disposal procedures by industries. The adoption of the available

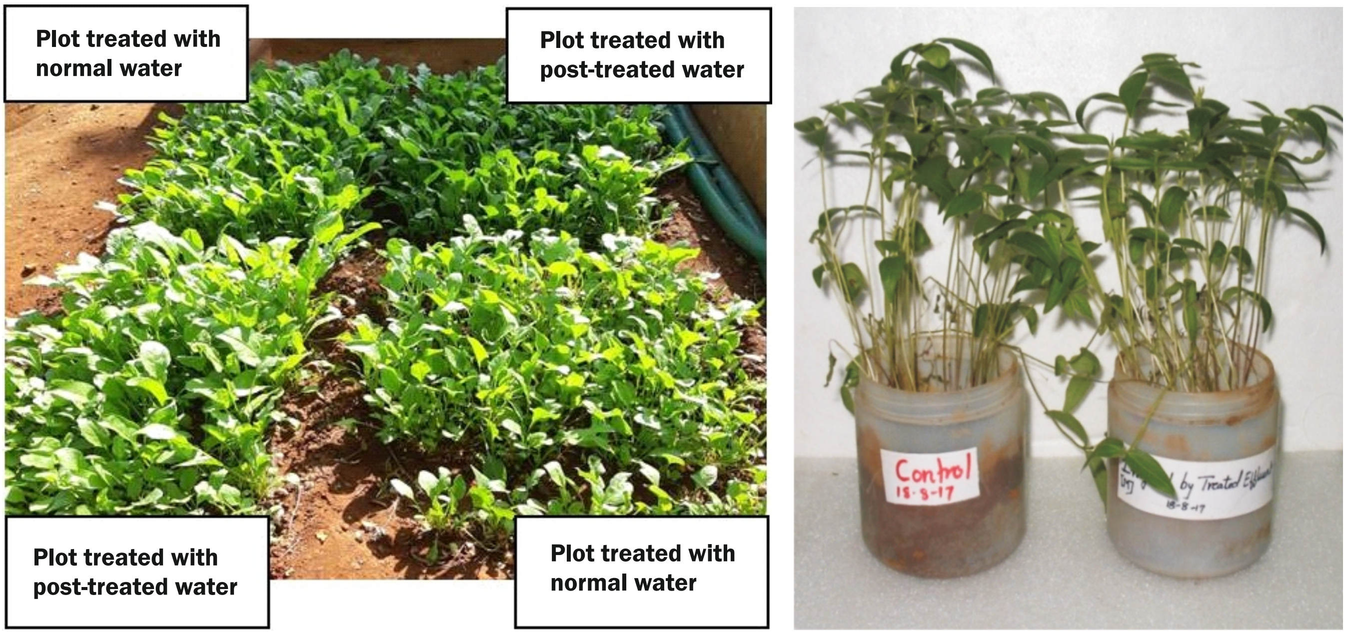

Fig.3: Effect of post-treated effluent water on the growth of Spinach and Mungbean.

technologies for treating the effluent is lacking either due to difficulties in implementation or in-efficiency of the technologies as reported by Padalkar and Rakesh Kumar [6]. In view of this, the system reported in the present study is highly efficient with a potential for deployment at higher scale. This system gainfully integrates the microbial, filtration and nanoparticle technologies in a coherent manner and thereby successfully reduces the toxic components of industrial effluent realizing thus a valuable nutrient enrichment of water for irrigation purpose. The key advantages of present system lie in its simplicity of design, economics, ease of operation, scalability and maintenance. Different components used during present study are available locally, inexpensive and furthermore possess the economically much desirable attribute namely the recyclability as and when called for.

Conclusion

Globally, industrial waste water treatment systems are facing enormous challenges due to water shortage and contamination of water resources. Due to this, there is a paradigm shift from waste water treatment to resource recovery and repurpose. In order to utilize the treated effluent for land applications, bringing the contaminants levels to the acceptable level is one part but it is also important to bring about the value addition in the post treated effluent in order to enhance its usability. Industrial waste water treatment system developed in the present study addresses both these important issues and makes water more suitable for irrigation purpose. Also, it offers the attractive possibility of in-situ processing of the waste water generated at source industry thereby is considered to be an important a major advance step towards achieving the goal of commercially attractive decentralized effluent treatment.

Thus, this three-stage effluent treatment system has served multiple roles in restoration of water quality, reduced water pollution and ensured a wholesome plant growth. Our studies clearly indicate that the industrial effluent waste water problems can gainfully be solved by this novel process. The present method represents new multi-faceted field deployable strategy towards securing a quality water supply for agricultural applications.

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