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ScienceDirect
Chemosphere 67 (2007) 1229–1235
CHEMOSPHERE
www.elsevier.com/locate/chemosphere

Mutagenicity evaluation of industrial sludge from common effluent treatment plant

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Received 3 January 2006; received in revised form 12 June 2006; accepted 23 October 2006
Available online 19 December 2006

Abstract

Sludge from common effluent treatment plant (CETP) receiving effluents from textile industries at Mandia Road, Pali, was analyzed to assess the level of mutagenicity. Mutagenicity assay using *Salmonella typhimurium* tester strains TA 98 and TA 100 gave positive results, thus suggesting presence of genotoxic contaminants in the samples investigated. Further, mutagenic activity of chemical sludge was found to be lesser than that of biological sludge. This result is very surprising and unexpected as it is indicating that some mutagenic compounds are either being formed or certain promutagenic compounds are being converted into stable mutagenic metabolites during the biological treatment of the wastewater effluents. There have been no previous reports giving similar or contrary results. Most of the previous studies have reported effects of single combined sludge.

Keywords: Industrial sludge; Common effluent treatment plant; Chemical sludge; Biological sludge; Mutagenicity; Ames test

1. Introduction

Pali, with a population of 18 19 201 people, is an important district of Rajasthan. It has a geographical area of 12 387 Sq. kms. and is located between 24.45° to 26.75° North Latitude and 72.48° to 74.20° East Longitude. Pali is situated on the banks of River Bandi. It has got 989 textile industries, which is the largest number in the State of Rajasthan, mostly engaged in cotton and synthetic textile printing and dyeing.

These industries liberate a variety of chemicals, dyes, acids and alkalis besides other toxic compounds like heavy metals. Considerable amounts of dyes have been noticed in the textile wastewaters, due to their incomplete use and washing operations. The grave pollution situation that exists in and around Pali has been extensively studied (Garg et al., 1981; Gupta et al., 1983; Mohnot and Dugar, 1987; Agarwal and Kumar, 1990; Gupta and Jain, 1992; Khandelwal, 1996). Chhoakar et al. (2000) characterized the effluents emanating from Pali, and reported high salinity, BOD (400–800 mg/l) and COD (900–1500 mg/l); excessive concentration of sodium and carbonate ions; low concentrations of calcium and high alkalinity (pH 10.0–11.5) in the textile effluents.

The presence of potentially toxic compounds in wastewaters from dye houses has lead to environmental research to identify methods that can effectively treat this wastewater (Vandevivere et al., 1998; Rai et al., 2000). Properly designed waste treatment systems can remove or destroy many of the harmful contaminants in textile wastewaters, producing an effluent that can be safely discharged to receiving waters (Cha et al., 1999). Central Pollution

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0045-6535/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.chemosphere.2006.10.073

Control Board (India) in its comprehensive industry document series has advised setting up of common effluent treatment plant (CETP) for small and medium scale textile dyeing units (Central Pollution Control Board, 1990) like those in Pali.

Thus effluents from 487 textile industrial units located in industrial area, Mandia road, Pali are collected through surface drains into a treatment plant called common effluent treatment plant (CETP). This plant treats only industrial waste from these textile dyeing and printing industries.

The water after treatment at the CETP is released into the Bandi River. This treatment plant also generates huge amounts of solid sludge, which is currently being stored in open air, on plastic sheets. Sludge or solid waste generated at plants treating textile and dyeing industries wastewaters are likely to contain variety of different organic and inorganic chemicals, besides all the contaminants of effluents like dyes, heavy metals, detergents, etc.

Mutagenicity of municipal sludge is well documented. Absence of mutagenic contaminants in municipal sludge has been reported in a number of studies (Clevenger et al., 1983; Ottaviani et al., 1993). However, Hopke et al. (1982) reported positive results for Chicago municipal sludge. Analytical surveys of sludge from large cities (Mumma et al., 1988) and small towns (Mumma et al., 1983) have also revealed presence of a wide range of toxicants and low levels of mutagenicity in several of the sludge's tested. However, limited information is available on industrial sludge, like those at Pali. Proper disposal or usage of this sludge is a major environmental concern in Pali. As the composition of sludge from different sources varies considerably, sludge must be analyzed before it can be safely disposed. There is a strong possibility that there may be genotoxic compounds present in sludge.

Short-term genetic bioassays like Ames assay have proved to be an important tool in genotoxic studies because of their simplicity, sensitivity to genetic damage, speed, low cost of experimentation and small amount of sample required. This study was thus conducted to assess the mutagenicity of the industrial sludge produced at two different stages of treatment at CETP, Pali using Ames assay.

2. Materials and methods

2.1. Common effluent treatment plant

Chemists routinely check the quality of influent and effluent waters in the laboratory of this plant. However only physico-chemical parameters i.e. BOD, COD, pH and total suspended solids (TSS) are monitored. Further no monitoring is done for the large quantities of solid sludge that is generated during two levels of the treatment (Fig. 1).

2.2. Chemical sludge

The wastewater effluents from various industries are collected and mixed in the Equalization tank of the plant. Then in the Chemical dosing tank $FeSO_4$ and other coagulants like alum, lime, polyelectrolytes are added. pH neutralization is also done here. In Primary clarifloculator, settling or sedimentation removes suspended solids and colloidal matter. The supernatant liquid is pumped to the activated sludge basin while settled sludge is sent to the sludge drying beds. This sludge is referred to as chemical sludge.

2.3. Biological sludge

The supernatant coming from Primary clarifier is given biological treatment in activated sludge basin. In Secondary clarifier the sludge is separated and sent to drying beds. This sludge is referred to as biological sludge. The clear supernatant is discharged as effluent water into the Bandi River.

2.4. Sludge drying beds

Sludge thus obtained after chemical and biological treatment is dried in drying beds. The dried sludge is then dumped on plastic sheets, in open air, near the Bandi River.

2.5. Site selection and sampling

The solid sludge samples for the present study were collected from the plant during April and October, year 2000 and 2001. Unlike most of the previous studies, the chemical and biological sludge samples were not pooled together. They were analyzed separately. Sludge samples were powdered and dissolved in sterile, distilled water by keeping them on a rotary shaker, at 37 °C for 24 h. Samples were filter sterilized.

2.6. Ames mutagenicity test

The Salmonella/microsome reversion assay was conducted using the plate incorporation procedure described by Maron and Ames (1983). TA 98 and TA 100 strains of *S. typhimurium* were obtained from Microbial Type culture collection & Gene Bank (MTCC), Institute of Microbial Technology (IMTech), Chandigarh (INDIA). Samples were tested on duplicate plates in two independent experiments. Five dose levels of individual samples were tested. Positive controls used without metabolic activation were 2-nitrofluorene (CAS Number: 607-57-8) for TA 98 (2.5 μg/plate: 208 revertants) and Sodium azide (CAS Number: 26628-22-8) for TA 100 (5 μg/plate: 2969 revertants). Sterile distilled water was used as negative control (Spontaneous revertants without metabolic activation: TA 98: 42 revertants and TA 100: 142 revertants). Fresh solutions of the reference mutagens were prepared immediately before the beginning of each experiment. Sterile distilled water was used as negative control. All tester strains were maintained and stored according to the standard methods (Mortelmans and Zeiger, 2000). The strains