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EFFECT OF SALINITY ON THE REDUCTION OF SULPHATES AND DEGRADATION OF ORGANIC POLLUTANTS BY *DESULFOVIBRIO DESULFURICANS*

Reduction of sulphates (SO_4) and degradation of organic matter (COD) by *Desulfovibrio desulfuricans* were examined. The nutrient medium – which consisted of liquid manure from an industrial pig farm – was treated with NaCl varying in the concentration from 0 to 10 g/dm^3. The degradation of the two polluting species was found to depend on the salinity level. At NaCl concentrations between 0 and 2 g/dm^3, there was a continuing increase in the reduction efficiency and reduction rate of both SO_4 and COD. Once the concentration value of 2 g/dm^3 NaCl had been exceeded, reduction efficiency and reduction rate decreased continually.

1. INTRODUCTION

Salinity is the major factor that affects the efficiency of biological treatment. As it can be inferred from the reported investigations, high concentrations of salts carried by the wastewater to be treated may seriously inhibit the biological process involved, thus contributing to very poor treatment effects irrespective of the micro-organisms and method applied. MILLS and WHEATLAND [1] demonstrated the adverse effect of saline sewage on the performance of percolating filters. TOKUZ and ECKENFELDER [2] showed how inorganic salts affected the efficiency of the activated sludge process. Similar findings were reported by LUDZACK and NORAN [3], KINCANNON and GAUDY [4], or BERNACKA and co-workers [5]. KOSTECKI [6] studied the effect of salinity on the course of the denitrification process, whereas BOLSUNOWSKIJ and ZOTINA [7] reported on how the increased salinity levels influenced the growth of the cyanobacterium *Spirulina platensis*. BOSZCZYK and CEBULA [8] observed that an NaCl concentration from 5 to 10 g/dm^3 of wastewater noticeably inhibited cell lysis, flocculation and respiration of activated sludge, as well as the nitrification process.

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As shown by these data, the salinity problem cannot be neglected when developing the method of biological treatment, the more so as the concentration of inorganic salts increases continuously not only in municipal sewage but also in industrial effluents.

The objective of the present study was to investigate how the presence of NaCl influences the efficiency and rate of sulphate (SO_4) and organic matter (COD) degradation brought about by the sulphate-reducing bacterium *Desulfovibrio desulfuricans*.

2. MATERIAL AND METHODS

Microorganisms. The sulphate-reducing strain *D. desulfuricans* was isolated from the hydrogen sulphide sources of the spa of Busko Zdrój [9]. The micro-organisms were adapted to the nutrient medium prior to inoculation [10].

Media. The *D. desulfuricans* strain was grown on the liquid manure from an industrial pig farm. The medium was treated with appropriate NaCl portions (to provide salt concentrations ranging between 0 and 10 g/dm^3) and had the following chemical parameters:

pH	6.71–6.84,
total alkalinity (mval/dm^3)	26.8–28,
$COD_{(after\ filtration)}$ (mg O_2/dm^3)	1809–2000,
SO_4 (mg SO_4/dm^3)	2387.

Salt concentration, expressed as a sum of SO_4^{2-} and Cl^- ions in the medium, varied from 2637 to 8787 mg/dm^3. The COD/SO_4 ratio ranged between 0.76 and 0.84, which is optimal for the process, as shown elsewhere [11].

Bacterial culture. *D. desulfuricans* cultures were grown in air-tight glass reactors with 2-dm^3 effective volumes, at 38 °C. Growth was discontinued when no variations in the concentration of sulphates were measured.

Analytical methods. Sulphates, COD, and rate constants of organic matter degradation and sulphate reduction were determined by the methods reported elsewhere [11].

3. RESULTS AND DISCUSSION

The experiments showed that the efficiency of sulphate reduction and organic matter degradation depended on the concentration of salts in the wastewater (figure 1). Initially, the increase of NaCl concentration had a favourable effect on the degradation of both the pollutants, maximum efficiency being achieved at a salt concentration of 2 g/dm^3. Thus, relevant values for SO_4 amounting to 11.8%, 45.3% and 76.7% were obtained after 18 h, 90 h and 164 h, respectively (the rate constant of COD degradation being 15%, 47.3% and 63.8%, respectively). Once the salinity level had exceeded 2 g/dm^3, the reduction of SO_4 and degradation of COD were inhibited.

Analysis of the process dynamics revealed that a low salt concentration enhanced the reduction of both SO_4 and COD (figure 2). The rate of the process was the fastest at the NaCl concentration equal to 2 g/dm^3. When salinity increased, the rate constant decreased rapidly.

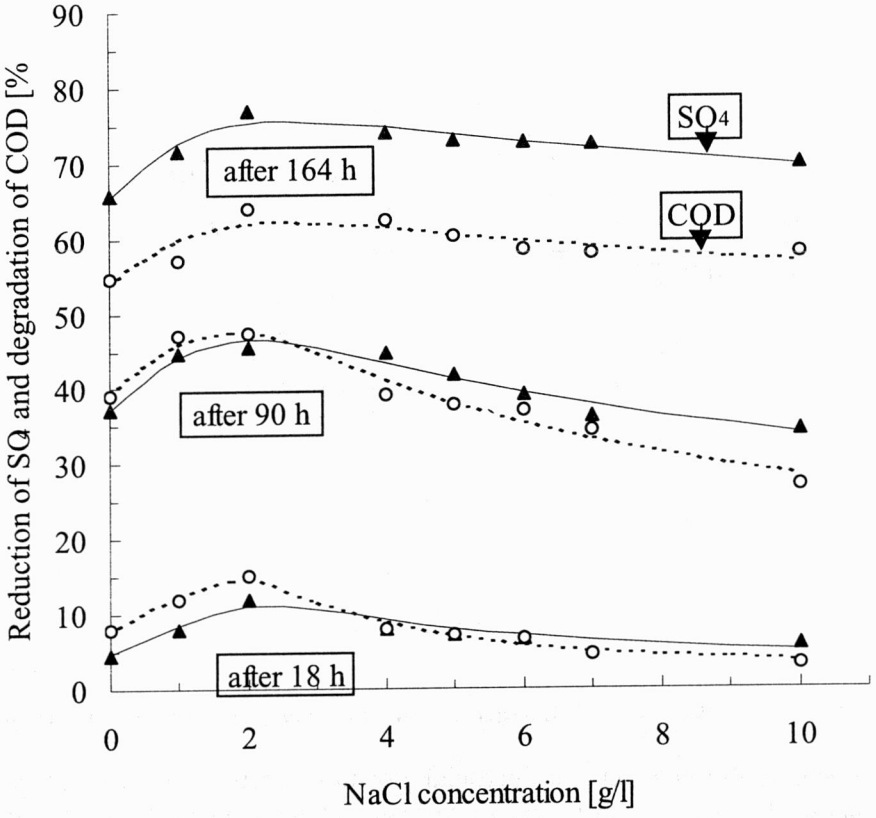

Fig. 1. Reduction of SO_4 and degradation of COD by *D. desulfuricans* versus salt concentration

The activity of the *D. desulfuricans* strain was found to be inhibited by the high salinity of the environment (the presence of NaCl). One of the contributing factors was the osmotic pressure, which increased with the increasing salinity level, thus inhibiting conversion of the matter due to a serious deformation of the cell membrane. These phenomena were clearly illustrated by the results reported by KHATTABA and co-wokers [12] who examined the effect of salinity on the mycelia *Aspergillus flavus* and *Aspergillus parasiticus* and detected a close relationship between the morphological changes of the mycelium and the osmotic pressure induced by the addition of NaCl.

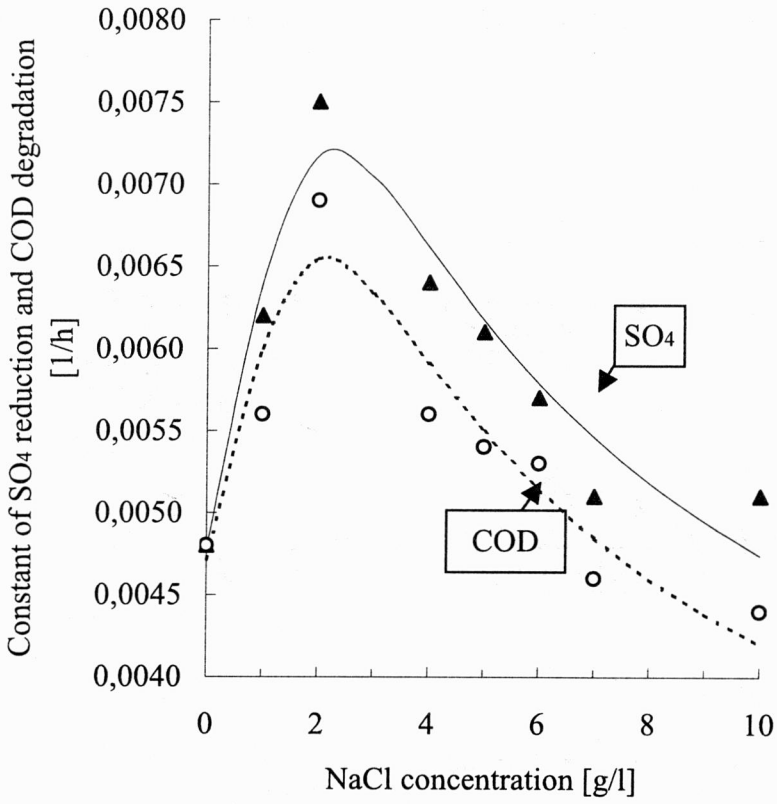

Fig. 2. Rate of SO_4 reduction and COD degradation by *D. desulfuricans* versus salt concentration

It is a well-established fact that microbial growth and activity are also affected by the cations in the salt. However, the mechanisms of these interactions are still far from being well understood. In spite of many attempts, we have not been able to define the mechanism responsible for the cell tolerance for the cations in a medium. In their recent report, GARCIA and co-workers [13] postulated that the salt tolerance in *Candida tropicalis* and *Saccharomyces cerevisiae* yeast should be attributed to the glucose-induced catabolic regulation.

The results of our experimental study allow the following generalisations to be made:

1. *D. desulfuricans* tolerance for salt (NaCl) is low.

2. Initially, the increase of NaCl concentration had a favourable effect on the degradation of both pollutants. Once the salinity level had exceeded 2 g/dm^3, the reduction of SO_4 and degradation of COD were inhibited.

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USUWANIE SIARCZANÓW I ZANIECZYSZCZEŃ ORGANICZNYCH PRZEZ *DESULFOVIBRIO DESULFURICANS* W ZALEŻNOŚCI OD ZASOLENIA ŚCIEKÓW

Badano rozkład siarczanów i zanieczyszczeń organicznych (COD) przez bakterie siarczanowe *D. desulfuricans* w podłożu stanowiącym ścieki z przemysłowego tuczu trzody chlewnej, do którego dodano NaCl w ilości od 0 do 10 g/dm^3. Wykazano, że rozkład obydwu zanieczyszczeń zależał od zawartości NaCl w podłożu. Zwiększającemu się stężeniu soli (od 0 do 2 g/dm^3) towarzyszyła poprawa zarówno efektywności, jak i szybkości rozkładu siarczanów i COD, ale w miarę dalszego wzrostu stężenia soli stopniowo malała efektywność i szybkość usuwania obydwu zanieczyszczeń.