OPEN ACCESS

International Journal of Applied Sciences and Biotechnology

A Rapid Publishing Journal

ISSN 2091-2609

Available online at:

http://www.ijasbt.org
&
http://www.nepjol.info/index.php/IJASBT/index

Indexing and Abstracting

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CODEN (Chemical Abstract Services, USA): IJASKD

Vol-2(2) June, 2014

IC Value: **4.37**

SEM-Biotech Publishing

ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

DEGRADING AND DETOXIFYING INDUSTRIAL WASTE WATER USING BIOREMEDIATION APPROACH

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Abstract

Bioremediation uses various microorganisms to detoxify or degrade various harmful substances in the nature, particularly soil and water. In the ~~proposed~~ work, five species of micro-organisms were used to analyse their impact on various physico-chemical parameters of water. In the first attempt the actual physico chemical parameters of the collected sample water were noted down (Fresh sample parameters). Then the sample water was treated with micro-organisms (one at a time). The growth of microbes was noted carefully over 96 hours after inoculation. The physico chemical parameters were recorded again and were compared with the fresh sample parameters. The results were analysed for any change and on this basis an impact factor was developed.

The study reveals all the selected microbes have a great capacity of degrading and simplifying the complex molecules into simpler ones. Bioremediative treatment further enhances this capacity and therefore this approach can be utilized on large scale to minimize pollution of water bodies.

Key Words: Microbes; heavy metals; light; waste water;toxicity

Introduction

According to an estimate, world over, water pollution causes approximately 14,000 deaths per day, mostly due to contamination of drinking water by untreated sewage and industrial effluents in developing countries. High levels of pollutants mainly organic ones cause great damage to the receiving water bodies (GNA, 2013).

Bioremediation is an effective method to degrade and detoxify various pollutants in the water bodies. It uses simple micro-organisms that consume and degrade various organic pollutants. Bioremediation is a cost effective and efficient approach to reduce environmental pollution (Megharaj *et al*., 2011).

The proposed work was carried out at Mathura (U.P.), India, which has great religious importance, being the birth place of Lord Krishna and holy river Yamuna. More than a dozen industries are working here in the famous industrial area. The waste water from these industries in being directly poured into river Yamuna, which is life threatening for aquatic organisms.

The main aim of this work concentrates on the effectiveness of the use of some common microbes in improving the quality of water taken from some industrial sources.

Materials and methods

Water samples were collected each month in pre sterilized cleaned, dry, polyethylene bottles which was previously washed with 20 % nitric acid and subsequently with de-mineralized water. Samples were collected each month from two wide drains, which directly receive industrial outlets. The contents from both the sites were mixed together, soon after collection. This mixture was used as the sample for laboratory work. One part of the sample was analysed for physico-chemical parameters in the laboratory using APHA (1989) guidelines. The parameter tested include – phosphate, nitrate, sulphate, chromium, COC and TDS. The other part of the sample was used for bio-remedial treatment.

Following five important microbes were selected for analysing their impact in improving the quality of water. These are –

1. *Rhodobacter sphaeroides,*
2. *Acinetobacter calcoaceticus,*
3. *Streptomyces rochei,*
4. *Bacillus subtilis*
5. *Pseudomonas aruginosa*

Pure cultures of these bacterial species were obtained from the various sources.

A stirred tank type bioreactor was used for analysing bioremediation impact. One litre of sample water was used in the bioreactor and it was added with inoculum and growth media. The inoculum contained one test organism at a time. The growth was allowed for 96 hours. At different intervals i.e., at 24 hours, 48 hours and 96 hours, the change in physico-chemical parameters of the sample water was recorded and compared with the original sample (fresh sample). For each micro-organism, three samples were analysed (one each month) and an average of the three was finally considered.

Results and Discussion

The results have been summarized in following Table 1.

The effect of bioremediation was expressed in the form of a simple ratio, called "impact factor". It was calculated as below –

Impact factor = (Fresh sample average values - 96 hour average values) / 96 hour average values

The value more than zero (i.e., positive value) represents a reduction in the amount of concerned parameter i.e., good bio-remediative effect. On the other hand the value less than zero (i.e., negative value) represents an increase in the amount of concerned parameter i.e., poor effect.

Rhodobacter sphaeroides is a purple eubacterium with an extensive metabolic repertoire. *Rhodobacter* exhibited a negative impact factor on sulphate , nitrate and TDS. The rise in the sulphate value is an indicator of increasing BOD values, since the organism is a good producer of oxygen by photosynthesis. The oxygen then causes oxidation of various organic sulphides and sulphites to sulphates (Kalpan, 2005). The rise in the nitrate values also indicates increasing oxygen contents which in turn promotes the oxidation of various reduced forms of nitrogen including ammonia, urea and nitrites (Young *et al*., 2003). The rise in the T.D.S. should not be taken as increase in the pollution load. This is mainly because of increasing number of nitrates and sulphates in the mixture due to increasing oxidation of nitrogen and sulphur compounds. Rhodobacter has shown a positive impact on phosphates i.e., it decreased the values of phosphate during experiment. A tremendous positive impact of *Rhodobacter* was seen on COC contents and on chromium. The remarkable capacity of *Rhodobacter* for chromium was noted by Nepple *et al*. (2000).

Acinetobacter calcoaceticus are strictly aerobic, non-fermentative, gram negative bacilli. *Acinetobacter* exhibited a positive impact on the sulphates. The fall is observed probably because the organism respires aerobically (Abdel-El- Haleem, 2003) and consumes oxygen quickly, so, deriving its oxygen from sulphate ions. The value of phosphate was also decreased from 5.09mg/l to 1.86 mg/l. Acinetobacter exhibited a positive impact on nitrates, COC, chromium and on TDS. i.e. a decrease in the value of these parameters was observed.

Streptomyces are gram positive bacteria, which live mainly as saprophytes. *Streptomyces* exhibited a positive impact on the sulphate and phosphate. The value of sulphates was decreased from 38.18mg/l to 32.23 mg/l. Phosphates was decreased from 4.83 mg/l to 3.90 mg/l. A decrease in the value of nitrates was also noted. The reduction in the sulphate value is also due to terminal reduction reactions of nitrate assimilation. A considerable positive impact was noted on COC contents, on chromium and on TDS. The decrease was mainly because of the decrease in the number of major anions and metal cations.

Table 1: A comparison of Fresh sample (FS) parameters and parameters after 96 hours of bioremediation

		Sulphate	**Phosphate**	**Nitrate**	**COC**	**Metal**	**TDS**
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Rhodobacter sp.	FS value	30.54	4.95	78.12	0.13	0.32	1054.67
	96hr value	41.26	3.27	93.12	0.05	0.18	1182.67
	Impact factor	-0.26	0.51	-0.16	1.71	0.8	-0.11
Acinetobacter sp.	FS value	33.16	5.09	94.56	0.13	0.23	1207
	96hr value	26.94	1.86	86.91	0.04	0.07	1016.33
	Impact factor	0.23	1.74	0.09	2.25	2.14	0.19
Streptomyces sp.	FS value	38.18	4.83	95.79	0.12	0.31	1121
	96hr value	32.23	3.9	87.57	0.05	0.26	985.33
	Impact factor	0.18	0.24	0.09	1.31	0.18	0.14
Bacillus sp.	FS value	41.7	4.3	77.24	0.15	0.14	1047
	96hr value	31.79	2.98	68.51	0.05	0.1	984
	Impact factor	0.31	0.44	0.13	1.93	0.39	0.06
Pseudomonas sp.	FS value	36.61	5.14	105.78	0.12	0.2	1246
	96hr value	27.83	3.85	82.58	0.05	0.06	1035.67
	Impact factor	0.32	0.34	0.28	1.4	2.16	0.2

Bacillus subtilis is a bacterium, which live mainly as saprophytes. They are well known for their antibiotic properties. *Bacillus* exhibited a positive impact on the sulphates, a great positive impact on the phosphates, from 4.30 mg/l to 2.98 mg/l. A decrease in the value of nitrates was noted. The value of COC was decreased from 0.15 mg/l to 0.05mg/l, which is nearly 66%. The value of chromium was decreased from 0.14 mg/l to 0.10 mg/l which indicate that it can well survive in water with metal toxicity. A positive impact factor on TDS was observed mainly because of the decrease in the values of nitrates, sulphates and phosphates.

Pseudomonas aeruginosa can catabolize a wide range of organic molecules. The value of sulphate was decreased from 36.61 mg/L to 27.83 mg/l. Kliushnikova *et al.* (1992) have noted that genus *Pseudomonas* has a great sulphates reducing power which gets enhanced under anaerobic conditions. It has shown a great positive impact on phosphates, nitrates, COC. The value of chromium was decreased from 0.20 mg/l to 0.06 mg/l, which is more than 70%. TDS reduction was noted due to reduction in the values of nitrates, sulphates and phosphates.

Conclusion

From the above discussion and analysis it could be concluded that all the selected microbes have a tremendous natural tendency to degrade complex compounds into simpler ones. The bioremediation approach simply augments the growth of micro-organisms in order to accelerate the natural process of degradation. If microbial digesters are used to treat industrial waste water before its disposal, not only we can save our rivers and other natural water bodies but also we can utilize this water for drinking, washing purposes.

Acknowledgement

The authors are thankful to the U.G.C. for providing financial assistance.

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