RESPONSE OF HYBRID ANAEROBIC REACTOR TO WASTE WATER TOXICITY

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by

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DEDICATION

I WOULD LIKE

TO DEDICATE

MY THESIS

TO MY

BELOVED PARENTS

CERTIFICATE

This is to certify that the thesis entitled, ***"Response of Hybrid Anaerobic Reactor to Waste Water Toxicity"***, being submitted by ***Ms. Pragya***, to the **Indian Institute of Technology Delhi**, for the award of the degree of ***Doctor of Philosophy***, is worth consideration. The thesis is a record of original bonafide research work carried out by her under my supervision and has been prepared in conformity with the rules and regulations of the institute. The results contained in this have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Increased generation of hazardous / toxic waste from various anthropogenic activities and their discharge into water bodies has resulted in severe water pollution. This is quite common with industries that generate wastewaters with high concentrations of toxic compounds, which need specialized treatment systems. As toxicity is one of the major reason for reactor failure, this work was taken up to study the response of a Hybrid Anaerobic Reactor to various toxic compounds present in wastewaters. Three different toxic compounds were studied viz: Cyanide, 4- Chlorophenol and Cr (VI).

In anaerobic wastewater treatment processes, anaerobes are quite sensitive to the toxicity conditions resulting in treatment limitations. In this study focus was on understanding their responses to toxicities and managing the treatment efficiently. Hybrid Anaerobic Reactor requires granulated sludge for the start-up which is a time consuming process. The present study tries to understand the effect of these toxic compounds on the sludge characteristics and granulation process.

The effect of wastewater toxicities were studied in both suspended cell and attached cell systems. The performance of Hybrid Anaerobic Reactor was much better than the suspended cell system in the toxic conditions, based on the inhibitory concentrations estimated. The IC_{50} values in case of suspended cell system were 40, 200 and 150 ppm for Cyanide, 4-CP and Cr (VI) treating batch reactors, respectively. However, in case of attached cell system these values were 60, 225 and 225 ppm, respectively. Both the chemical as well as microbial analyses were performed for these reactor systems. As such reactor systems treating various effluents have been in operation as “black-box” without any knowledge for the microbial

communities present in them. In this study, chemical performance of the reactors were correlated to their microbial community structures, which helped in tracking changes in the microbial populations, aiding efficient reactor operation. The results indicated hydrogenotrophs to be more tolerant to the toxic conditions. The analysis also suggested order *Methanobacteriales* to the most tolerant methanogenic guild and bacterial genus *Clostridium, Lactobacillus, Pseudomonas, Gordonia, Methylobacterium, Cellulomonas, Rhodococcus* etc. to be more tolerant to toxic conditions.

Based on the findings, wastewater from a coke oven plant was treated and communities were enriched with the tolerant groups. This resulted in improved reactor performances. Thus, the study established that toxicity affects microbial guilds and there is a strong link between reactor performance and microbial communities. The findings of the study can used to predict reactor behavior in such conditions.

सारांश

विभिन्न मानवीय गतिविधियों से उत्पन्न हुए खतरनाक/जहरीले कचरे को जल निकायों में छोड़ देने के कारण गंभीर जल प्रदूषण की स्थिति उत्पन्न हो गई है। उपरोक्त स्थिति उन उद्योगों के संबंध में काफी आम है जिनके द्वारा विषाक्त योगिकों की उच्च सांद्रता के साथ अपशिष्ट जल उत्पन्न किया जाता है तथा जिनको विशेष उपचार प्रणालियों की जरूरत है। चूंकि विषाक्तता रिएक्टर की विफलता का मुख्य कारण है, अतः इस काम को हाईब्रिड अवायवीय रिएक्टर की अपशिष्ट जल में मौजूद विभिन्न विषाक्त योगिकों के संबंध में प्रतिक्रिया का अध्ययन करने हेतु ग्रहण किया गया था। निम्न तीन विषाक्त यौगिको का अध्ययन किया गयाः साइनइड, 4 क्लोरोफिनोल तथा सी.आर. (VI)।

अवायवीय अपशिष्ट जल उपचार प्रक्रियाओं में, अनारोब्स विषाक्तता के लिए काफी संवेदनशीन होते है जिसके परिणाम स्वरूप उपचार में अनेकों रूकावटें उत्पन्न होती है। इस अध्ययन में उनकी विषाक्तता के लिए प्रतिक्रियाओं तथा उनके कुशलता से इलाज के प्रबंध को समझने पर ध्यान केंद्रित किया गया है। हाईब्रिड अवायवीय रिएक्टर को शुरू करने के लिए दानेदार कीचड़ की आवश्यकता होती है जो कि समय लेने वाली प्रक्रिया है। वर्तमान अध्ययन उपरोक्त जहरीले यौगिको का कीचड़ की विशेषताओं तथा कणिकायन प्रक्रिया पर प्रभाव को समझने की कोशिश करता है।

अपशिष्ट जल विषाक्तता के प्रभाव का अध्ययन दोनों सस्पैन्डिड सैल तथा अटैच्ड सैल प्रणाली द्वारा किया गया। अनुमानित निरोधात्मक सांद्रता के अनुसार, हाईब्रिड अवायवीय रिएक्टर का प्रदर्शन विषाक्त परिस्थितियों में सस्पैन्डिड सैल प्रणाली की तुलना में बेहतर था। सस्पैन्डिड सैल प्रणाली में साइनाइड, 4 सी.पी. तथा सी.आर. ;अपद्ध का शोधन करने वाले बैच रिएक्टर में आई.सी. 50 मूल्य क्रमशः 40, 200 एवं 150 पी.पी. एम. थे। जबकि अटैच्ड सैल प्रणाली में यह मूल्य क्रमशः 60, 225 एवं 225 पी.पी.एम. थे। इन सभी रिएक्टर प्रणालियों के सम्बन्ध में दोनों रसायनिक एवं माइक्रोंबियल विश्लेषण किये गये थे। क्योंकि विभिन्न अपशिष्टों के शोधन में प्रयोगः हुई रिएक्टर प्रणालियों को उनमें मौजूद माईक्रोबियल समुदायों की बिना किसी जानकारी के ही ''ब्लैक बॉक्स'' के रूप में चलाया जा रहा है। इस अध्ययन में, रिएक्टरों के रसायनिक प्रदर्शन को उनकी माईक्रोबियल समुदाय संरचनाओं से सहसंबद्ध किया गया जिससे माइक्रोबियल आबादी में हुए परिवर्तनों को समझने में मद्द मिली तथा कुशल रिएक्टर ऑपरेशन में सहायता मिली। परिणामों से यह संकेत मिला की

हाईड्रोजनोट्रोफस विषाक्त स्थिति को अधिक सहन कर सकते है। विश्लेषण से यह भी संकेत मिला की ऑर्डर मैथानोबैक्टेरियल्स सबसे अधिक सहनशील मैथानोजेनिक गिल्ड है तथा बैक्टेरियल जिनस, क्लोस्ट्रीडियम, लैक्टोबेसीलियस, सीयोडोमोनास, गोरडोनिया, मिथाईलओबैक्टीरियम, सैल्यूलोलूमोनास, रहोडोकोकस इत्यादि विषाक्ता की स्थिति में अधिक सहनशील है।

जांच– परिणामों के आधार पर कोक ओवन संयंत्र से प्राप्त अपशिष्ट जल का शोधन किया किया गया तथा समुदायों को सहनशील समूहों से समृद्ध किया गया। इसके परिणामस्वरूप रिएक्टर के प्रदर्शन में सुधार हुआ। इस प्रकार अध्ययन से यह स्थापित हुआ कि विषाक्ता माईक्रोबियल मंडली को प्रभावित करती है तथा रिएक्टर प्रदर्शन एवं माईक्रोबियल समुदायों के बीच एवं मजबूत कड़ी है। इस अध्ययन के जांच–परिणामों का प्रयोग रिएक्टर के व्यवहार को प्रीडिक्ट करने में किया जा सकता है।

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NOMENCLATURE

AFBR	ANAEROBIC FLUIDIZED BED REACTOR
COD	CHEMICAL OXYGEN DEMAND
CP	CHLOROPHENOL
Cr (VI)	HEXAVALENT CHROMIUM
DGGE	DENATURING GRADIENT GEL ELECTROPHORESIS
HAR	HYBRID ANAEROBIC REACTOR
HRT	HYDRAULIC RETENTION TIME
MBT	*METHANOBACTERIALES*
MCC	*METHANOCOCCALES*
MMB	*METHANOMICROBIALES*
MSC	*METHANOSARCINACEAE*
MST	*METHANOSAETACEAE*
NMDS	NON- METRIC MULTIDIMENSIONAL SCALING
OLR	ORGANIC LOADING RATE
PCA	PRINCIPAL COMPONENT ANALYSIS
PCR	POLYMERASE CHAIN REACTION
PLR	POLLUTANT LOADING RATE
PRE	POLLUTANT REMOVAL EFFICIENCY
PRR	POLLUTANT REMOVAL RATE
Q-PCR	QUANTITATIVE POLYMERASE CHAIN REACTION
SEM	SCANNING ELECTRON MICROSCOPY
SLR	SLUDGE LOADING RATE
SRB	SULFATE REDUCING BACTERIA
SRT	SLUDGE/ SOLIDS RETENTION TIME
TSS	TOTAL SUSPENDED SOLIDS
UASB	UPFLOW ANAEROBIC SLUDGE BLANKET
VFA	VOLATILE FATTY ACID
VSS	VOLATILE SUSPENDED SOLIDS