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# FUNGAL BIOSORPTION: AN ALTERNATIVE TO MEET THE CHALLENGES OF CR (VI) POLLUTION IN AQUEOUS SOLUTION

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**ABSTRACT**
The removal of heavy metals from the effluent is now shifting from the use of conventional physicochemical methods to biological methods using live or dead biomass of bacteria, yeast, fungi the process is broadly referred as biosorption. The process is based on the metal binding capacity of biomass under different conditions. In the present study use of *Aspergillus niger* and *Mucor hiemelis* biomass is used to remove hexavalent chromium from metal containing solutions. Effect of various parameters influencing metal sorption like, pH, temperature, biomass concentration, metal concentration etc. are also studied.

**KEY WORDS:** Biosorption of Chromium (VI), *A. niger, M. hiemelis*

## INTRODUCTION

The discharge of heavy metals into the water bodies is grossly contaminating these ecosystems and has become a matter of concern throughout the world over the past few decades. The majority of toxic metal pollutants are waste products of industrial and metallurgical processes. Their concentrations have to be reduced to meet the new regularity norms of the government. Among all the heavy metals copper, cadmium, nickel, zinc, chromium are the major pollutants which when ingested beyond the permissible limit, cause health hazards to the biota of aquatic ecosystems.

Fungi are very well known for heavy metal sorption. Fungi species are typically associated with heavy metal rich substrates and can be even considered as hyper accumulators of heavy metals (Purvis and Halls, 1996).Alternatively, fungi can be exposed to heavy metals from the atmosphere and are very well known from bio-monitoring studies focused on heavy metal pollution (Garty, 2001).

Filamentous fungi have shown great potential in biosorption by a live mode (dependent mode on the metabolic activity) known as bioaccumulation or by passive mode (sorption and/or complexation) termed as biosorption (Muralidharan *et.al.*, 1991). The high percentage of cell wall contents shows excellent metal binding capacity (Rosenberg, 1975). Zajic and Chiu (1972) were one of the first to investigate fungal biomass for practical applications of biosorption. They discovered that heat deactivated biomass of *Penicillium sp*. could absorb more uranium. Since then many fungi both unicellular and filamentous have been tested for their biosorption capacity. The main objectives of the study was to determine the possibilities for using fungal biomass in biosorption of chromium which is one of the most frequent heavy metal found in wastewaters. Growth independent sorption of Cr (VI) by dried fungal biomass study by *Asp. niger* and *M. hiemelis* is studied in this paper.

## MATERIALS AND METHODS

- Dried fungal biomass of *A. niger, M. hiemalis*
- Cr (VI) stock solution (100ppm)

Biosorption experiments were carried out to study the effect of :
1. Initial Cr (VI) concentration was carried out by inoculating 100ml (50-200ppm) of metal solution by 1% dried biomass of *Asp .niger* and *M. hiemelis* with pH 7.0for 1hr at $30^0$ C
2. Initial inoculum concentration was studied by inoculating 50ppm of 100ml of Cr (VI) of pH 7.0 by (1% to 5%) of dried fungal biomass.
3. Effect of holding time was carried out by inoculating 50ppm of Cr(VI) solution with pH 7.0 at $30^0$ Cand incubating for 1-5 hrs
4. Effect of pH (3,5 7,9 and11) was carried out by inoculating 50ppm Cr (VI) on metal sorption by keeping other condition constant.

  

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5. To study the effect of incubation temperature 100ml Cr (VI) solution of pH 7.0 was inoculated with 1% biomass and incubated at various temperatures from $10^0$ C to $50^0$C.

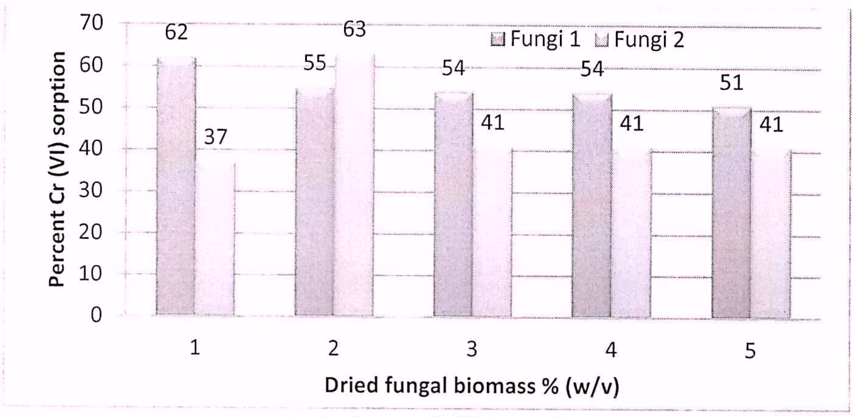
All the flasks were kept on a rotary shaker allowed to react as described above. Optimization of various parameters influencing on percent sorption of Cr (VI) were carried out as mentioned above. After retention time the reactions were terminated by centrifuging at 8000rpm and the supernatant was analysed for residual metal concentration using AAS. From it % metal sorption was calculated.

## RESULTS AND DISCUSSION

### 1. Effect of initial biomass of *A. niger, M. hiemalis* (w/v) on percent Cr (VI) sorption

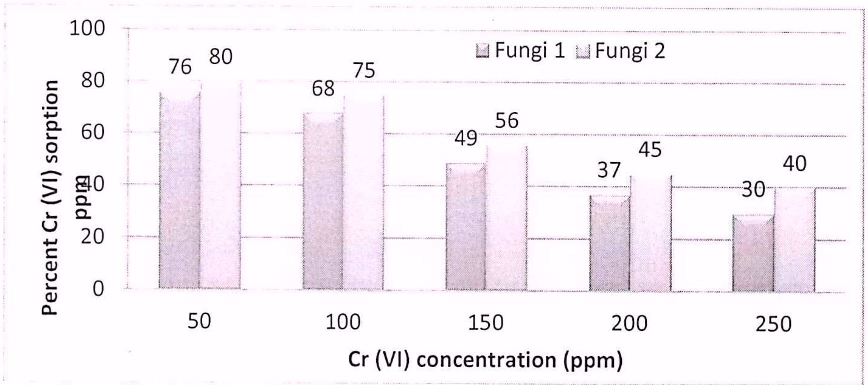
The capacity of biosorption of Cr (VI) by *A. niger* and *M. hiemalis* biomass is strongly dependent on its concentration. From Fig. 1, it was observed that in case of *A. niger* the maximum 62% of Cr (VI) sorption was at 1 % (w/v) inoculum concentration. In case of *Mucor hiemalis* it was 63% at 2 % (w/v) inoculum concentration. Further, it was observed that increase in their biomass concentration showed decrease in percent sorption. The reduction in the Cr (VI) sorption by biomass may be due to the decrease in the distance between the cells (Fourest and Roux, 1992).

**Fig 1: Sorption of Cr (VI) by various inoculum concentrations of *A. niger and M. hiemalis* biomass**




*1. A. niger 2. M. hiemalis*

**Fig.2: Percent sorption of Cr (VI) at different Cr (VI) concentration by *A. niger and M. hiemalis* biomass**

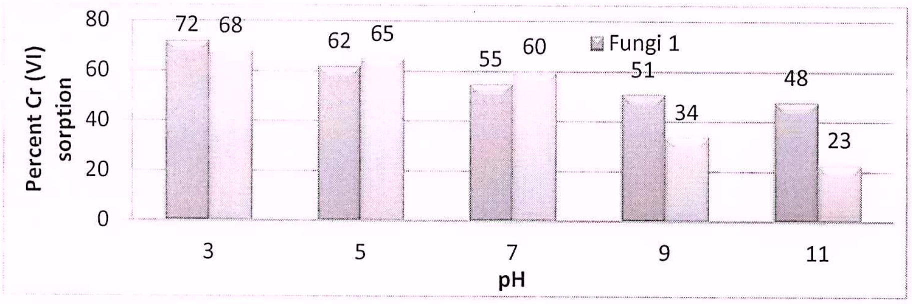



*1. A. niger 2. M. hiemalis*

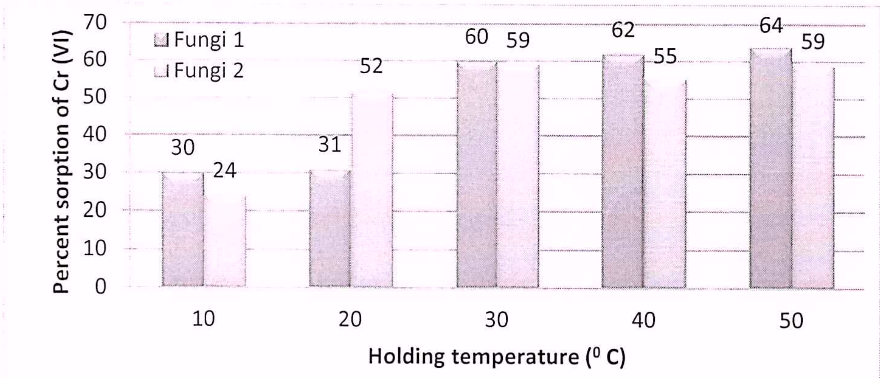
2. Effect of initial concentration of Cr (VI) on percent Cr (VI) sorption by *A. niger* and *M. hiemalis* biomass
The percentage Cr (VI) adsorbed was highest at 50 ppm of Cr (VI) and there was a decrease percent adsorption when initial Cr (VI) concentration was increased (Fig. 2). Maximum percent sorption of Cr (VI) by *M. hiemalis* was 80% at 50ppm followed by *A. niger* (76%) at the same Cr (VI) concentration. Increase in Cr (VI) concentration showed that the percentage Cr (VI) removal dropped significantly. This might be due to the lack of available active sites and the metal adsorption process will increasingly slowed down. Similar observations were reported by the adsorption of nickel containing dye on activated carbon and adsorption of nickel on fly ash (Purkait *et.al.*2005).

**Fig. 3: Percent sorption of Cr (VI) at different pH values by *A. niger* and *M. hiemalis* biomass**




*1. A. niger 2. M. hiemalis*

**Fig. 4: Percent biosorption of Cr (VI) by fungal biomass at different holding temperatures**




*1. A. niger 2. M. hiemalis*

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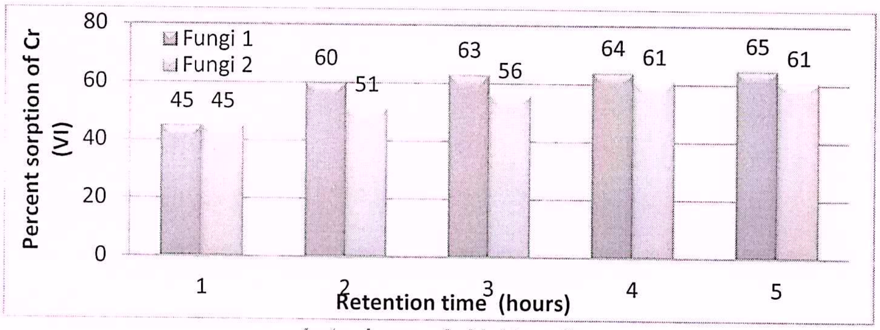
Fig. 5: Percent sorption of Cr (VI) at different retention time by *A. niger* and *M. hiemalis* biomass




*1. A. niger* *2. M. hiemalis*

**3. Effect of pH on percent Cr (VI) sorption by *A. niger* and *M. hiemalis* biomass**

From the Fig. 3 it can be evident that the selected 2 fungal isolates showed maximum percent adsorption of Cr (VI) at 3.0 pH. *A.niger* showed maximum 72% and *Mucor hiemalis* 68% as pH increased beyond 7.0 there was decrease in percent sorption of Cr (VI).

**4. Effect of holding temperatures on percent Cr (VI) sorption by *A. niger* and *M. hiemalis* biomass**

Adsorption studies were carried out at 5 different temperatures (10-50$^0$C) and keeping the Cr (VI) and adsorbent dose constant. It was observed that in both the adsorbent fungal biomass at 30$^0$C there was 60% absorption (Fig. 4). Further increase in holding temperature showed slightly increase in adsorption thereby indicating the adsorption as an endothermic process with increase in temperature the number of active sites available for adsorption must have increased resulting in enhancement of percent adsorption of Cr (VI). Venkatsewerlu and Stotzky (2000) who reported that cobalt binding was not affected by increase in temperature in *Cunninghamella blakesleeana*.

**5. Effect of retention time on percent Cr (VI) sorption by *A. niger* and *M. hiemalis* biomass**

From the results presented in Fig. 5, it was observed that sorption of Cr (VI) by fungi was a fast process. Experimentally, it was observed that both the fungal biomass adsorbed Cr (VI) very fast i. e. within 1 hr of contact it reached to 45%. After which percent sorption of Cr (VI) increased slightly and reached to 63% for *A. niger* after 3 hrs of incubation afterwards it remained constant and in case of *M. hiemalis* it reached 64% after 4hrs of incubation. Generally, biosorption is a very rapid process, completing within few hours (Aksu 1992). After some time equilibrium is established, when the biomass becomes saturated and no further increase in biosorption is observed.

## CONCLUSION

Fungi can be of interest for metal biosorption because fungi are able to remove heavy metals from aqueous solutions in substantial quantities; in certain instances the removal of heavy metal ions has been observed to be more than that by conventional absorbents (Williams *et.al.,* 1998).Further from the studies it can be observed that fungal biosorption has been studied more extensively because of the availability of large amounts of waste fungal biomass from fermentation industries.(Zhou and Kiff, 1991). Many fungal species have low nutritional requirements and are versatile in physical growth conditions .Biomass separation from the growth medium constitutes a simple operation .Dead biomass can be subjected to physical and chemical treatments to enhance its performance and the particle size can be optimized (Brady *et.al.* 1994).

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