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International Journal of Current Research
Vol. 7, Issue, 09, pp. 20493-20498, September, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

CO-REMOVAL OF PHENOL AND CYANIDE FROM WASTE WATER BY PHYTOREMEDIATION

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ARTICLE INFO

Article History:
Received 21st June, 2015
Received in revised form
30th July, 2015
Accepted 29th August, 2015
Published online 30th September, 2015

Key words:
Carbohydrate, Chlorophyll, Cyanide, Normalized Relative Transpiration (NRT), Phenol, Phytoremediation, Protein, Starch.

ABSTRACT

Various types of pollutants are present in wastewater discharges form coke industry, but cyanide and phenol are considered as most dangerous pollutants among all. Due to the utilization of natural sources, the phytoremediation is considered as a low cost method which utilizes natural sources. In the current research, Co-removal of cyanide and phenol from waste water was done by *E. Crassipes* (Water Hyacinth) and *Zea Mays* (Maize) plants with the application of the phytoremediation method. The toxicity measurement of cyanide and phenol to the plants was determined with the help of Normalized relative transpiration, Biomass growth, change in length of stem and root. The percentage removal of cyanide and phenol was determined at different concentration of cyanide and phenol.

Citation: Anupama Kumari and Majumder, C. B. 2015. "Co-removal of phenol and cyanide from waste water by Phytoremediation", *International Journal of Current Research*, 7, (9), *20493-20498*.

INTRODUCTION

There are various treatment methods to treat the wastewater discharges from coke plants such as adsorption, leaching, precipitation, ion exchange, oxidization and membrane separation, etc. (Young and Jordan 1995). But these wastewater treatment methods have some advantages and disadvantages. The cost and some technical problem are some disadvantages of these methods (Vedula *et al* 2013). Hence, to overcome these problems another treatment method is introduced named as phytoremediation. This method is not harmful for the environment and is an economical alternative method for the remediation of polluted wastewater (Salt *et al.,* 1995, Vangronsveld *et al.* 2009). It uses the plants and related microorganisms for the pollutants present in the wastewater (Meers *et al.,* 2010). Phytoremediation is termed as an effective, economical and suitable method for the environment which can be used as alternative remediation method for the wastewater treatment (Witters *et al.,* 2012). Wastewater discharged from coke industries contains toxic pollutants such as xenobiotics, phenols and its derivatives, cyanide, rhodanate and ammonia. The concentration of phenol and cyanide in coke oven wastewater is 1000 mg/l and 300 mg/l respectively (Wild *et al*1994). Cyanide and thiocyanates reduces the enzyme activity of the unicellular organisms (Raef *et al.,* 1977).

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Phenol can reduce the activity of the enzyme at low concentrations (Suschka *et al.,* 1994, Papadimitriou *et al.,* 2009). The presence of cyanide can cause tremors, rapid breathing and several other neurological effects, even at low concentrations and the presence of cyanide can cause thyroid effects, weight loss, neutral damage at hog concentrations. Presence of phenol can causes coma, cyanosis, skin irritations and convolutions. (UEPA 1980). CPCB, USEPA and MINAS set the maximum permissible limit in drinking water at 0.2 mg/l for cyanide (Akcil *et al*, 2003) and 0.5 mg/l for phenol (Ohio EPA 2002), respectively. Several studies have been done on the phytoremediation method for the removal of phenol and cyanide, which depicts that various plants are pursuing in the environment which can be utilized for the remediation of water after discharges from coke industries (Vedula *et al.,* 2013). Hence, these contaminants present in wastewater require a treatment and remediation of these pollutants become a major problem in current days. Various phytoremediation experiments for the removal of phenol and cyanide by different plant have been discussed in Table 1.

Transpiration Measurements

Transpiration is the best parameter for the toxicity measurement because the change in mass in plant system by transpiration is 300 times larger than by the growth The toxic effects of pollutants on plants are compared with the variation in transpiration rate. Weight loss is expressed as the relative transpiration. This is normalized with respect to initial transpiration and the transpiration of uncontaminated plants. This is because of the fact that each plant has different transpiration rates and the healthy plant can grow during the phytoremediation experiment.

Table 1. Phytoremediation experiments for phenol and cyanide by several plants

Authors	Plants	Pollutants
Ebbs et.al, 2003	Basket Willow trees	Cyanide
Xiaozhang et.al, 2007	Weeping willow	Cyanide
Mathias et.al, 2007	Water Hyacinth	Cyanide
Weaver Oller et.al, 2005	Tomato	Phenol
Singh et.al 2008	Vetiver	Phenol
Santos de Arauji et.al 2002	*Daucus Carota*	Phenol
Agostini et.l 1997,2003	*Brassica Juncea*	Phenol
Singh et.al 2006	*Brassica Juncea*	Phenol

The mean normalized relative transpiration (NRT) is calculated by the eqution (1).

$$NRT(C,t) = \frac{\frac{1}{n}\sum_{i=1}^{n}\frac{T_i(C,t)}{T_i(C,0)}}{\frac{1}{m}\sum_{j=1}^{m}\frac{T_j(0,t)}{T_j(0,0)}} \quad \text{………………(1)}$$

Where C is concentration (mg/l), it is the time period (hr), T is absolute transpiration (g/hr), n and m are the number of replicates for exposed plants and control plants (Trapp *et al* 2000).

Studies of Metabolic Parameters

The metabolic studies were done using the observation of metabolic parameters such as Chlorophyll a, Chlorophyll b, Protein, Carbohydrates and Starch. These metabolic parameters were calculated for the various concentrations of phenol and cyanide (Mane *et al.,* 2011).

Chlorophyll measurement

Chlorophyll measurement was done by the UV Spectrophotometer at the end of the phytoremediation experiment on the plants. The concentration of chlorophyll a and chlorophyll b were determined using the equation (2) and (3) (Maclachalam *et al* 1963).

$$C_a = \frac{(12.3D_{663} - 0.86D_{645})V}{100*d*W} \quad \text{…………………(2)}$$

$$C_b = \frac{(19.3D_{645} - 3.60D_{663})V}{100*d*W} \quad \text{…………………(3)}$$

Where C_a is the chlorophyll a concentration (mg/g FW), C_b is the chlorophyll b concentration (mg/ g FW), D is the optical density (OD) at the specific wavelength indicated, V is the final volume (ml), W is the fresh weight of leaf materials (g), and d is the length of the light path (cm).

MATERIALS AND METHODS

All *E.Crassipes* and *Zea Mays* plants were planted into Hoagland solution which provide nutrients for the growth of plants (Mathias *et al.,* ?). The initial concentration of phenol and cyanide was taken as 0, 20, 40, 60, 80 and 100 mg/l for *E.Crassipes* plants and 5, 15,25 and 35 mg/l for *Zea Mays* plants. The weight, length of root and stem were measured and analyzed for the variation in these parameters at different concentrations. Biomass production of the plant was measured by weighing the each plant before and after the experiment. Normalized relative transpiration Maize plants were calculated by weighing the plant with pot every day interval. Water use efficiency of plants has been calculated by the ratio of growth of plants and transpiration.

RESULTS AND DISCUSSIONS

Normalized Relative Transpiration (NRT)

Figure 1 shows the variation in % NRT with time for the co-removal of phenol and cyanide. At lower concentration of phenol and cyanide the transpiration decreases to 55% approximately but for higher concentration of phenol and cyanide the transpiration approximately decreases to 18 % for *E. Crassipes* plants. Similarly, at lower concentrations of phenol and cyanide the transpiration decreases to 71%, approximately but for higher concentration of cyanide the transpiration approximately decreases to 33 % for *Zea Mays* plants. For control plants the %NRT decreases to 85%.

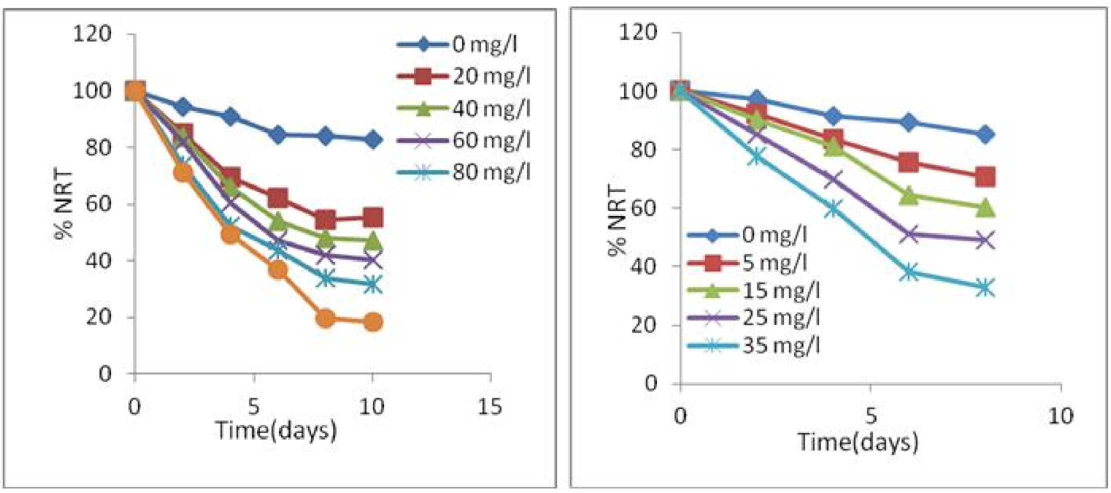

Figure 1. Variation in %NRT with time for *E. Crassipes* and *Zea Mays* plants

Effect of initial concentration

Figure 2 represents the variation in percentage removal of cyanide and phenol in the case of co-removal of phenol and cyanide. It was observed that the percentage removal of cyanide and phenol was decreased in increase in initial concentration.

The percentage removal of phenol decreases from 59% to 33% and the percentage removal of cyanide decreases from 53% to 26% for *E. Crassipes* plants and the percentage removal of phenol decreases from 37% to 23% and the percentage removal of cyanide decreases from 42% to 26% for *Zea Mays* plants.

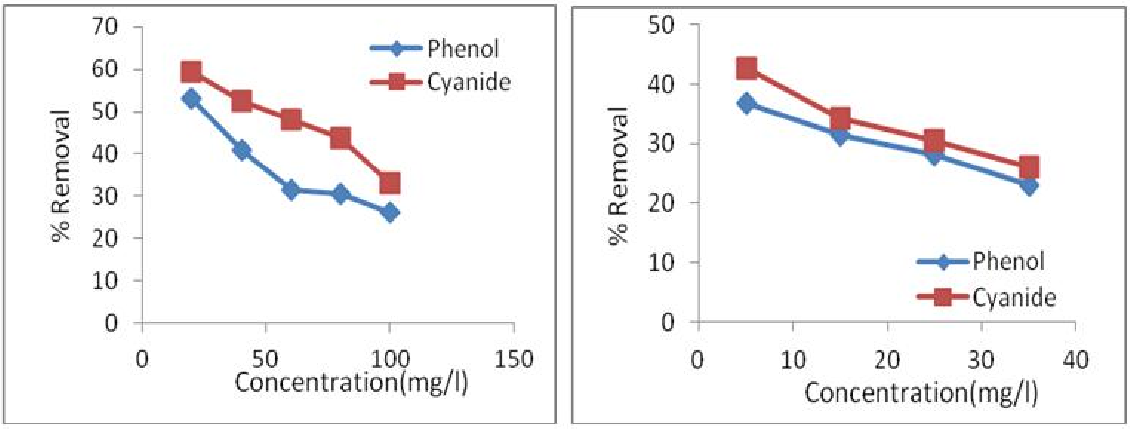

Figure 2. % Removal of phenol and cyanide at different Concentration for *E. Crassipes* and *Zea Mays* plants

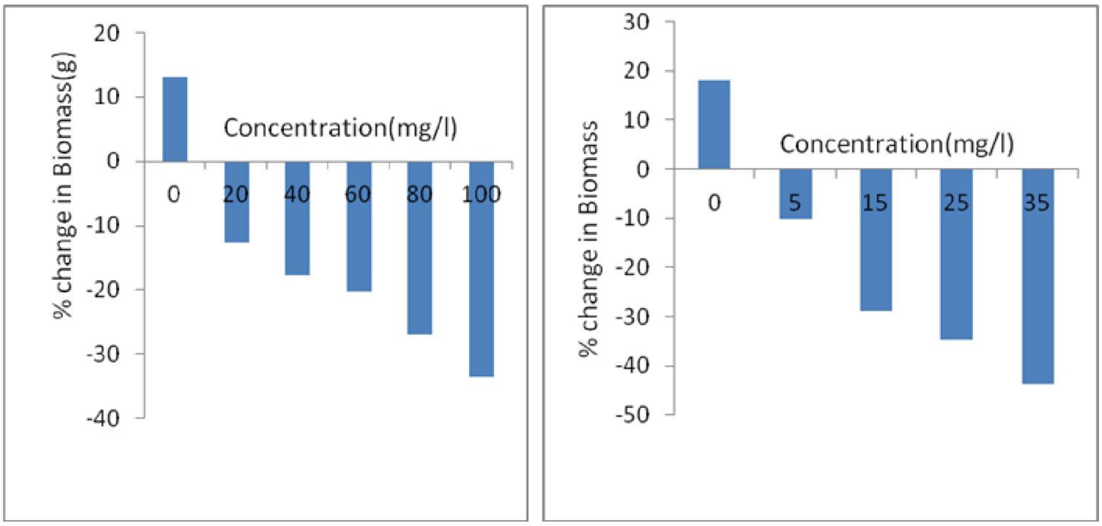

Figure 3. % Change in biomass at different concentration of phenol and cyanide for *E. Crassipes* and *Zea Mays* plants

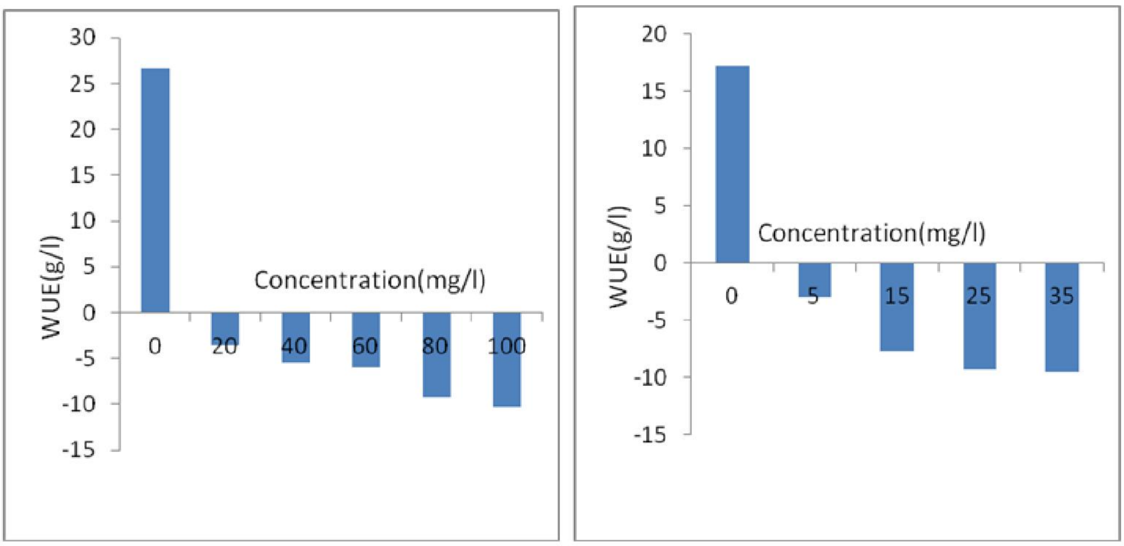

Figure 4. Water use efficiency of *E. Crassipes* and *Zea Mays* plants at different concentration of phenol and cyanide

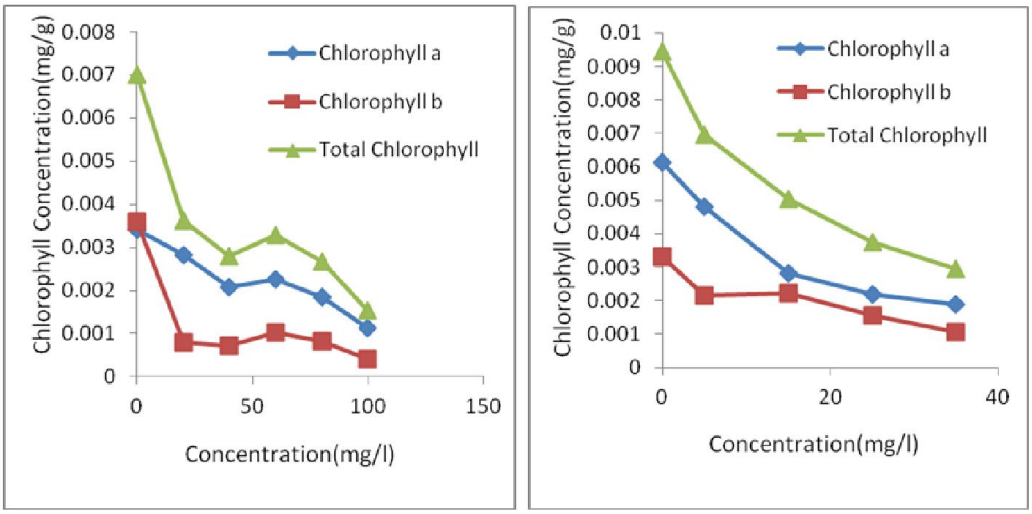

Figure 5. Chlorophyll concentration of *E. Crassipes* and *Zea Mays* plant at different concentration of phenol and cyanide

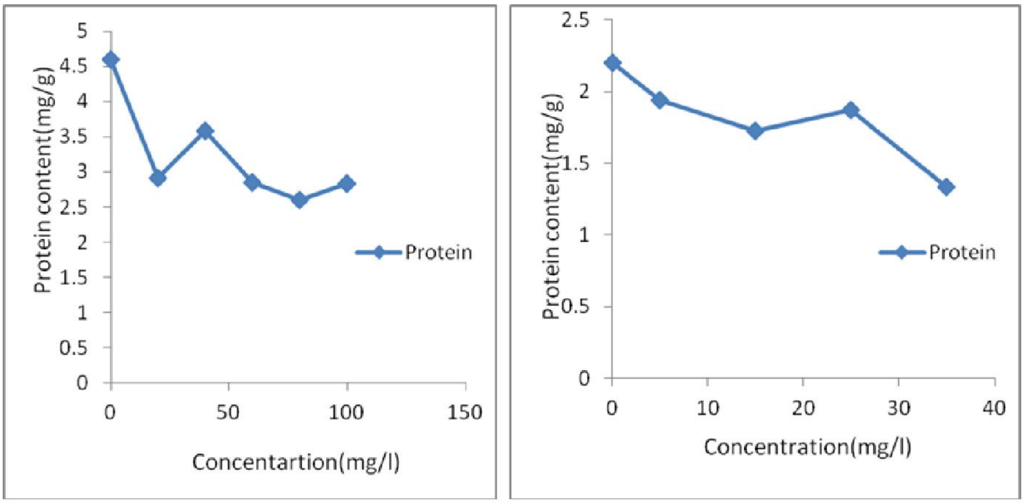

Figure 6. Protein content of *E. Crassipes* and *Zea Mays* plants at different concentration of phenol and cyanide

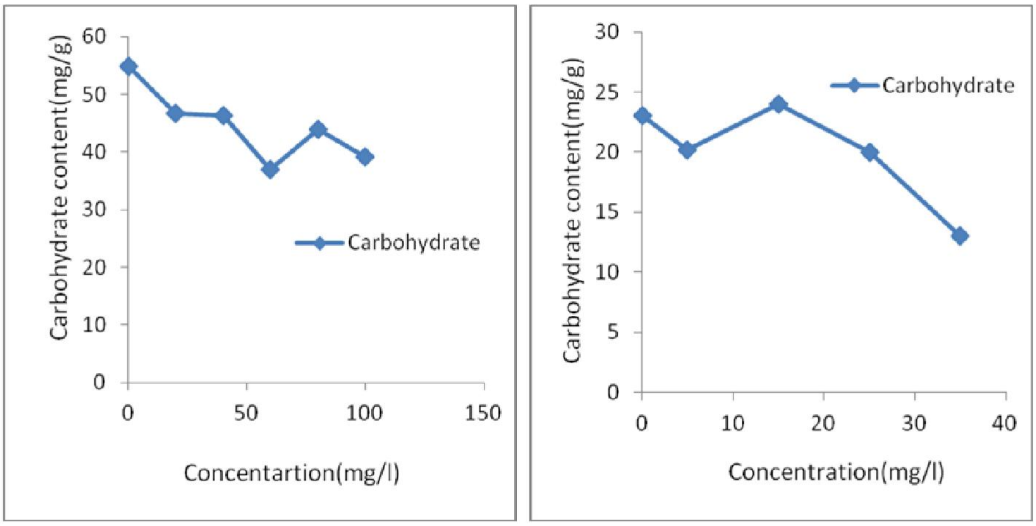

Figure 7. Carbohydrate content of *E. Crassipes* and *Zea Mays* plants at different concentration of phenol and cyanide

Biomass Growth

Figure 3 depicts the variation in percentage growth of biomass of *E. Crassipes* and *Zea Mays* plants at various concentration of phenol and cyanide for the co-removal of phenol and cyanide. At higher concentration the biomass of the plants reduced slightly and after 2 days the plants get green sick and died.

But at lower concentration the biomass of the plants reduced at a lower rate and died after 8 days. The percentage growth in biomass of plants at higher concentration is greatly reduced, but the percentage growth in biomass of plants at lower concentration is reduced but to lesser extent. But there is positive growth obtained in the biomass of plants for control.

Starch Content

Figure 8 shows the variation in starch content of *E. Crassipes* and *Zea Mays* at different concentration in the case of the Co removal of phenol and cyanide (Dubois *et al* 1956).

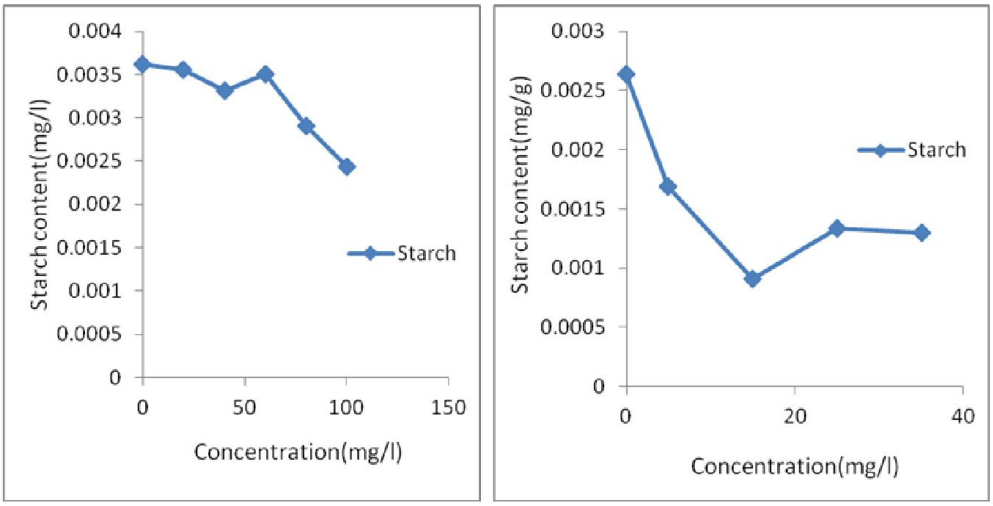

Figure 8. Starch content of *E. Crassipes* and *Zea Mays* plants at different concentration of phenol and cyanide

Water Use Efficiency

Figure 4 shows the variation in water use efficiency of *E. Crassipes* and *Zea Mays* plants at different concentration. For control plants, there is positive change in water use efficiency, but for the solution with phenol and cyanide concentration there is a negative change in Water use efficiency of plants. This negative change is obtained because of the lesser survival of the plants after 2-4 days. As the plants became green sick, the water use efficiency of plants decreases.

Study of Metabolic Parameters

The metabolic properties of *E. Crassipes* and *Zea Mays* plants are changing with concentration. The properties were examined before and after the exposure of plants at different concentration of phenol and cyanide. Metabolic properties have been also examined (Pramod *et al*., 2011).

Chlorophyll Measurement

Figure 5 show the variation in chlorophyll content of *E. Crassipes* and *Zea Mays* plants at different concentration in the case of Co removal of phenol and cyanide respectively (Pramod *et al*., 2011).

Protein Content

Figure 6 shows the variation in protein content of *E. Crassipes* and *Zea Mays* at different concentration in the case of the Co removal of phenol and cyanide (Lowry *et al*., 1951).

Carbohydrate Content

Figure 7 shows the variation in carbohydrate content of *E. Crassipes* and *Zea Mays* at different concentration in the case of the Co removal of phenol and cyanide (Dubois *et al*., 1956).

Conclusions

Co removal of phenol and cyanide by phytoremediation effects the percentage removal of phenol and cyanide. Due to the presence of both pollutants, plants died earlier and percentage removal also decreases. The percentage removal of phenol and cyanide by *E.Crassipes* planrs were 59% and 53% respectively and the percentage removal of phenol and cyanide for *Zea Mays* plants were 37% and 42% respectively. The %NRT was found to be 55% and 71% for *E.Crassipes* and *Zea Mays* plants, respectively. The negative growth was observed in the biomass growth and water use efficiency of both plants. The metabolic properties of plants changes at different concentration of phenol and cyanide.

Acknowledgement

Funds and help were provided by the Department of chemical engineering for my research. At this moment of accomplishment, first of all I pay homage to my guide, Mr. C.B Majumder. This work would not have been possible without his guidance, support and encouragement. It is also a pleasure to mention my good friends, Mr. Shantam Rastogi who are always there when I really needed. Finally, and most importantly, I would like to thank my family for their faith in me and allowing me to be as ambitious as I wanted.

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