Journal of Environmental Management 200 (2017) 46–52

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Clean up fly ash from coal burning plants by new isolated fungi *Fusarium oxysporum* and *Penicillium glabrum*

Burcu Ertit Taştan [a, b, c, *]

[a] Polatlı Faculty of Science & Arts, Gazi University, 06900, Polatlı, Ankara, Turkey
[b] Health Services Vocational School, Gazi University, 06830, Gölbaşı, Ankara, Turkey
[c] Life Sciences Application and Research Center, Gazi University, 06830, Gölbaşı, Ankara, Turkey

ARTICLE INFO

Article history:
Received 11 October 2016
Received in revised form
24 April 2017
Accepted 20 May 2017

Keywords:
Air pollution
Bioremediation
Coal
Fly ash
Fusarium oxysporum
Penicillium glabrum

ABSTRACT

In Turkey approximately 45 million tons of coals are burned in a year and 19.3 million tons of fly ash have emerged. The bioremediation of heavy metals or different elements from fly ash makes them bio-available. However, in previous studies, requiring of long operational time and failing to show tolerance to high pulp densities of fly ash of selected fungal species makes them impractical. In this work, bioremediation of fly ash by new isolated fungi *Fusarium oxysporum* and *Penicillium glabrum* were investigated in one step and two step bioremediation process. Ca, Si, Fe and S were found to be considerable amount in studied fly ashes by ED-XRF element analysis. The bioremediation yields of Mo (100%), S (64.36%) Ni (50%) and Cu (33.33%) by *F. oxysporum* were high. The remediated elements by *P. glabrum* in fly ash were Mo (100%), S (57.43%), Ni (25%), Si (24.66%), V (12.5%), Ti (5%) and Sr (3.2%). The isolation of high fly ash resistant fungi and reduction of the bioremediation time will allow the practical applications of the bioremediation technology when it is scaled up.

1. Introduction

Increased industrial activities cause the release of various materials from different sources to the environment. These materials effect to human health. One of them is fly ash and it constituted 98.6% of the total waste of thermal power plants. Fly ash is produced at 1200–1700 °C (Vassilev and Vassileva, 2005). The chemical properties of fly ash may depend on geological factors related to coals in power plants and different operating conditions (Siddique, 2010). The main components of the fly ash are SiO_2, Al_2O_3, Fe_2O_3 and CaO. It also consists of many of the toxic elements s i.e., Cr, Cd, Pb, Hg, As, Se etc and they make it a hazardous waste of the earth (Pandey and Singh, 2010).

In Turkey there are 59 thermal power plants by the year 2012. The amount of burned coal in these plants is approximately 45 million tons in a year. The emergent amount of wastes is 19.3 million tons per year (TUIK, 2012). According to the estimates 500 million tons of fly ash consists in a year in worldwide (Ahmaruzzaman, 2010). Therefore removing of fly ash is an extremely common problem and is making great economic efforts all over the world. In addition to the economic damages caused by the fly ash, it effects the environment and human health. Fly ash is classified as carcinogenic to humans (Borm, 1997; Ahmaruzzaman, 2010). The most harmful particle group of the fly ashes is smaller than 2.5 mm. Small particles of fly ash can easily penetrate into the lungs by respiratory system. The cost of health care results from the coal burning power plants is 55 trillion (Querol et al., 1995).

However the fly ash includes many of the contaminants, it has been recommended as a soil a substance in a lower dose that helps plants to grow basically by improving the conditions in agriculture (Pandey et al., 2009). The bioremediation of heavy metals from fly ash or red-mud makes them bio-available (Qu et al., 2013). The fly ash phytoremediation potential of some plants have been revealed (Pandey, 2012, 2016; Pandey and Mishra, 2016). The key problems of plant growth in fly ash have been reported as high pH, heavy metals toxicity, lack of nitrogen and organic matter (Pandey et al., 2012). On the other hand, a low cost and eco-friendly technology to bioremediate toxic metals associated with fly ash could be achieved by fly ash tolerant bacterial strains (Tiwari et al., 2008) and assisted phytoremediation process (Pandey, 2015).

The use of fungi in bioremediation of fly ash has become an increasingly important issue (Khan et al., 2014; Xu et al., 2014). *Aspergillus* genus is one of the most common studied fungi group.

* Polatlı Faculty of Science & Arts, Gazi University, 06900, Polatlı, Ankara, Turkey.
E-mail address: burcuertit@gazi.edu.tr.

http://dx.doi.org/10.1016/j.jenvman.2017.05.062
0301-4797/

Table 1
The experimental design of the study.

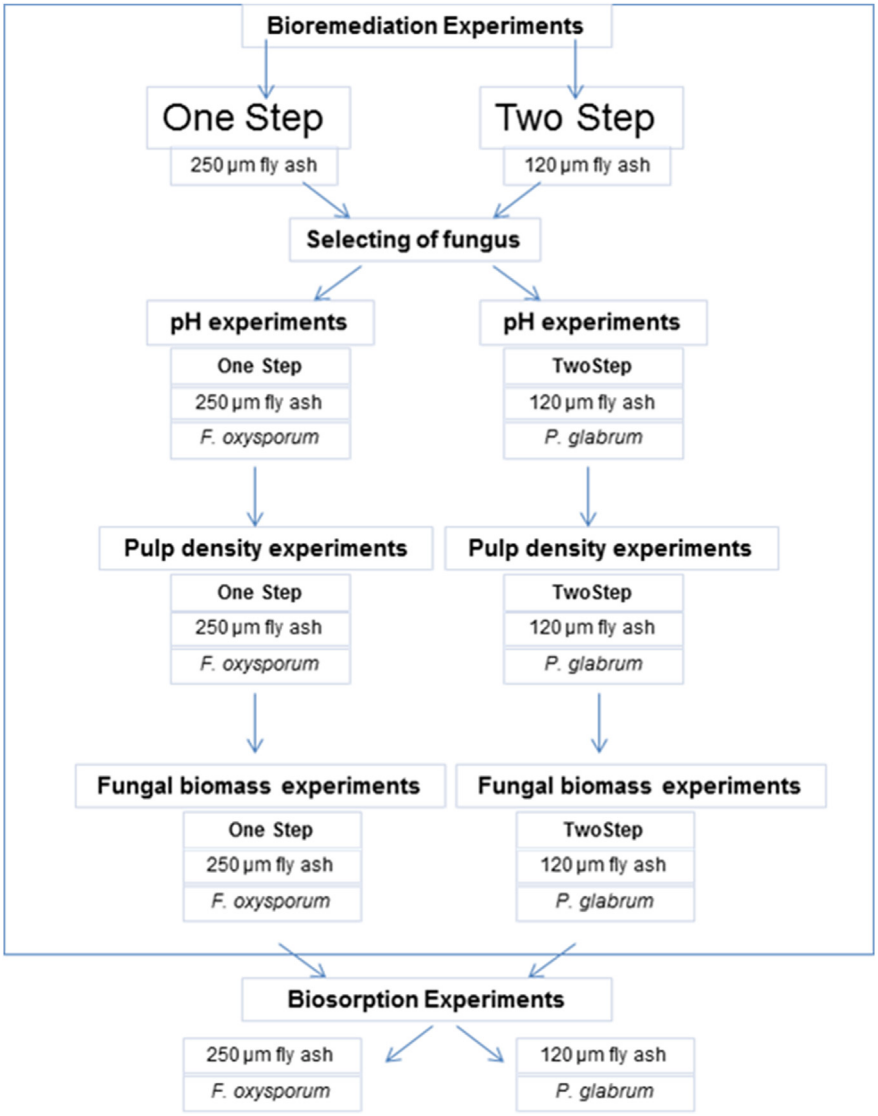

Table 2
Effect of different particle size of fly ash and different fungal species on bioremediation.

	Y %	q_m (mg/g)	μ (1/d)
	250 µm		
P. glabrum	76.82 ± 7.50	2.33 ± 0.25	0.233 ± 0.017
F. oxysporum	80.30 ± 5.68	2.45 ± 0.13	0.259 ± 0.009
	120 µm		
P. glabrum	94.83 ± 2.66	8.85 ± 0.97	0.195 ± 0.015
F. oxysporum	92.17 ± 7.25	12.04 ± 1.59	0.195 ± 0.015

T, 25 ± 2 °C; Shaking, 100 rpm; pH 6.
Incubation time: 7 days, fly ash concentrations; 1%.
q_m, the maximum specific fly ash uptake.
μ, specific growth rate; Y %, bioremediation yield.

However studies with *Aspergillus* species are revealed that these fungi failed to show tolerance to high concentrations of fly ash. The main goal of this study is to test the bioremediation capacities of *Fusarium oxysporum and Penicillium glabrum* at high density of fly ash in a cheap culture media and allow the practical applications for the bioremediation technology when it is scaled up.

2. Materials and methods

2.1. Fly ash

The incineration fly ashes were obtained from a coal burning plant in Turkey. Two different particle sizes of 250 µm and 120 µm fly ashes were evaluated. The ashes were autoclaved at 121 °C for 15 min before to use.

2.2. Isolation of fruit fungi

The fungi were isolated from *Apium graveolens* (celery) and *Ribes uva-crispa* (gooseberry) samples, which were obtained from Ankara (Turkey). The samples were spread on Petri plates containing Potato dextrose agar (PDA) media. The Petri plates were incubated at 30 ± 1 °C for 7 days. The fungal colonies that appeared on the plates were isolated and purified by streaking the cells repeatedly on the