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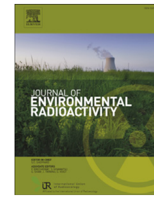

Effect of mineral constituents in the bioleaching of uranium from uraniferous sedimentary rock samples, Southwestern Sinai, Egypt

Maisa M. Amin [a], Ibrahim E. Elaassy [a], Mohamed G. El-Feky [a], Abdel Sattar M. Sallam [b], Mona S. Talaat [b], Nilly A. Kawady [a,*]

[a] Nuclear Materials Authority, Cairo, Egypt
[b] Faculty of Science Ain Shams University, Cairo, Egypt

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ABSTRACT

Bioleaching, like Biotechnology uses microorganisms to extract metals from their ore materials, whereas microbial activity has an appreciable effect on the dissolution of toxic metals and radionuclides. Bioleaching of uranium was carried out with isolated fungi from uraniferous sedimentary rocks from Southwestern Sinai, Egypt. Eight fungal species were isolated from different grades of uraniferous samples. The bio-dissolution experiments showed that *Aspergillus niger* and *Aspergillus terreus* exhibited the highest leaching efficiencies of uranium from the studied samples. Through monitoring the bio-dissolution process, the uranium grade and mineralogic constituents of the ore material proved to play an important role in the bioleaching process. The tested samples asserted that the optimum conditions of uranium leaching are: 7 days incubation time, 3% pulp density, 30 °C incubation temperature and pH 3. Both fungi produced the organic acids, namely; oxalic, acetic, citric, formic, malonic, galic and ascorbic in the culture filtrate, indicating an important role in the bioleaching processes.

1. Introduction

Bioleaching is a specialized biohydrometallurgical process principally based on the ability of microorganisms to transform solid compounds into soluble and extractable elements. The extracted elements could be removed through several techniques (Akcil and Deveci, 2010; Ehrlich, 2004). Metal prices, are not the only motivating factor for employing the biohydrometallurgical process (Brierley, 2008), cost production (Gericke et al., 2009; Moore, 2008) and difficulty in recognition as well as evaluation of ore deposits by conventional processes are among other factors (Brierley, 2010).

Fungal leaching of metals from minerals is mainly based upon three synchronous steps. *Acidolysis* which protonation of oxygen atoms that occurred around the surface of metallic compounds. The proton and oxygen associated with water displace the metal from the surface (Johnson, 2006; Mulligan et al., 2004; Xu and Ting, 2009). *Complexolysis*, where metal complex formation results in the solubilization of the metal ion e.g. complex of oxalic acid and iron. Furthermore, this process often reduces the toxicity of heavy metals towards fungi (Johnson, 2006). *Redoxolysis*, when reduction of metal ions occurs in an acidic environment, such as in the case of ferric ions and/or manganese under the influence of oxalic acid (Bromacher et al., 1997). A series of organic acids is formed by fungal metabolism, resulting in acidolysis complex and chelate formation (Mulligan et al., 2004). Lee et al. (2005) described the effect of several factors on uranium bioleaching efficiency of uranium bearing black shale (349 mg kg^{-1} of uranium) using *Acidothiobacillus ferrooxidans* (iron-oxidizer organism). They observed that the initial inoculations of bacterial cells of batch-type reactors, containing black shale, caused lowering of pH and highering of redox potential as well as of Fe^{3+} in the aqueous leach solutions over the non-inoculated reactor up to 200 h.

Ores are classified into high grade (where metal concentration is relatively high) and low grade (with low concentration of metals, like shale) (Chow et al., 2010). Shales are sedimentary rocks formed during the latter part of the Cambrian period and up to the first part of the Ordovician period, approximately 540–480 Ma ago (Falk et al., 2006). Their color is commonly tones of gray, brown, green or black due to the presence of some organic pigments in microbes inhibiting the shales. The introduction of quartz causes an increase in the size of their grains and transforms

* Corresponding author. Tel.: +20 (0)1008123944.
E-mail address: nillyKawady@yahoo.com (N.A. Kawady).

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them into sandstones. Shale deposits containing the elements Fe, K, Si and Al are most susceptible to microbial transformation (Harris, 2005; Piper and Calvert, 2009). The lower Carboniferous (upper Visean) Um Bogma Formation (Fig. 1) in the southern extreme of Wadi (Vally) Naseib consists of three members, namely lower sandy dolostone, middle siltstone marl intercalations and upper dolostone (Kora, 1984). Normally Karstification process affects the lower (sub-soil) and middle (top soil) to form another soil profile hosting several metallic forms (El Sharkawi et al., 1990). El Aassy et al. (2000) pointed out that lateritization processes affected all three members. These three members are the main target of this study.

The aim of this work focused upon using the different biomasses (fungi) isolated from three sedimentary samples (natural habitat) in the bioleaching of uranium from these samples.

2. Materials and methods

2.1. Collection of ore samples

To represent the Allouga mountain, in southern Wadi Nasieb, three radioactive geologically grapped samples were collected in sterile polyethylene bags from the prospective area in southwestern Sinai, Egypt. These samples (Table 1) were chosen to represent different grades of uranium concentrations.

2.2. Mineralogical and chemical analyses of studied samples

An X-ray diffraction technique was used to identify the mineralogical constituent of the study sample using (PHILIPS PW 3710/31) diffractometer with automatic sample changer PW 1775, (21

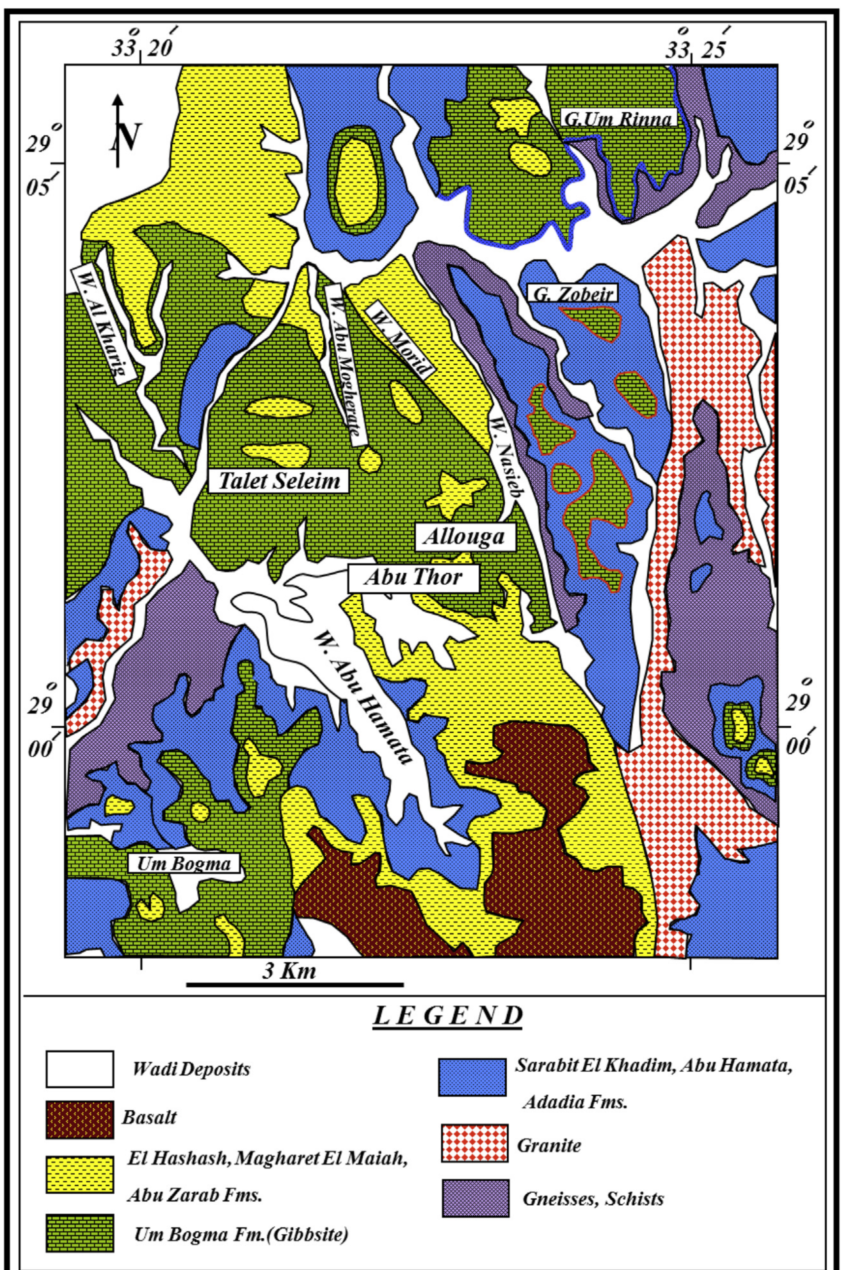

Fig. 1. Geological map of the studied localities, southwestern Sinai, Egypt (After, Alshami, 2003).