Assessment of Water Treatment Technologies in Removal of Heavy Metals from Drinking Water Sources at Greater Cairo

A Thesis Submitted for the degree of Master of Science as a partial fulfilment for requirements of the Master of Science

By

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(B.Sc. in Chemistry)

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Approval Sheet

M.Sc. Thesis

Entitled

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I. Introduction

Water of high quality is essential to human life and water of acceptable quality is essential foragriculture, industrial, domestic and commercial uses. All these activities are also responsible for pollutingthe water. Billions of gallons of waste from all these sources are thrown to freshwater bodies every day. Therequirement for water is increasing while slowly all the water resources are becoming unfit for use due toimproper waste disposal. The task of providing proper treatment facility for all polluting sources is difficultand also expensive, hence there is pressing demand for innovative technologies which are low cost, requirelow maintenance and are energy efficient. The adsorption technique is economically favorable andtechnically easy to separate as the requirement of the control system.

Aluminum sulphate (alum) is a common coagulant chemical in the water treatment industry. As a result, the Water Treatment Plants (WTPs) that use this chemical is highly focused in aluminum. Aluminum is the third most abundant metal on earth, making up 8% of the earth’s crust. When aluminum becomes mobilized, it can have toxic effects on the aquatic species living in surface waters. For example, acid rain can increase aluminum in the waters by releasing aluminum normally bound in soils and rocks. Due to the recent acidification of waters systems many studies have investigated the toxicity of aluminum on aquatic ecosystem. The increase in aluminum inthe receiving waters and the toxic effects it can have on aquatic species has led the Canadian Council of Ministers of the Environment (CCME) to impose aluminum discharge guidelines.

Natural zeolites showing cation exchange properties have been recognized in sedimentarydeposits of volcanic origin for more than a century. Theunique physical and chemical properties of zeolites, their capability of undergoing cationexchange and reversible dehydration, and their open framework structures liable to act asmolecular sieves, render zeolite as a sedimentary deposit of commercial value. Due tothese factors and combined with their geographically widespread abundance, zeoliteminerals have generated world-wide interest for use in a broad range of applications suchas nuclear and municipal waste, water treatment, stack-gas clean-up, natural gaspurification, petroleum production, and in agriculture and aquaculture.

Aim of the work

General objective of the present studyis to verifythe quality of the drinking water that produced from surface water treatment works with different treatment technologies. To achieve this purpose, water samples have been collected from six water treatment plants in Greater Cairo. The samples were drawn from raw water source (inlet) and final treated water (outlet) at the water treatment works. The quality of drinking water was verified by:

1- Testing physical and chemical parameters.
2- Testing microbiological parameters including bacteriological examination and microscopic examination for biological parameters.
3- The results of testing were compared with the Egyptian standard for drinking water (Ministerial Decree No. 458, 2007) to evaluate the compliance with the regulations. In addition the results were compared with the WHO guidelines for drinking water.

Another specific objective has been set as bench scale experiment to determine the removal of aluminum from drinking water using natural adsorbent, zeolite.

II. Literature Review

2.1. Egypt water resources

2.1.1. The Nile River

The Nile Riversupplies96%of Egypt’s fresh water. It is the longest river in the world, flowing approximately6.800km from south to north. Itsheadwaters stem from theRuvyironzaRiver in Burundi. The Nile Riverfinally ends its journey in the Nile Delta and the Mediterranean Sea **(EEAA,1999; DRI, 2000; Abdel-Gawad, 2002).**

The river basin includes ten states: Rwanda, Burundi, Congo, Tanzania, Kenya, Uganda, Ethiopia, South Sudan, Sudan and Egypt. The Blue Nile reaches a confluence with the White Nile at Khartoum after running1,500km from the east where Lake Tuna pours out of the Ethiopian highlands. The White Nile reaches Khartoum with its great volume from the inland sea of Lake Victoria north to Egypt where it meets Lake Nasser, a man-made lake formed by the Aswan High Dam. The dam was opened in1970and provides protection against floods and drought. It is also an important source of electric power. On the other hand, critics have claimed the dam prevents the natural flooding of the delta and hinders deposition of rich silt downstream. A major obstacle to increase water flow is a swamp in southern Sudan. In the 1930s, the British and Egyptians proposed a canal in order to decrease evaporation and to deliver more water downstream to Sudan and Egypt for use in agriculture. When the so-called Jonglei Canal is completed, the net increase in annual river flow will be 18 BM^3. A bilateral agreement between Egypt and Sudan stipulates that the water will be divided equally

Between the two states (Egypt and Sudan) and Ethiopia presently use the greatest portion of the river's water. Available Nile Riverwater in Aswan is estimated at 84 Bm^3 of which 10 BM^3 is lost through evaporation; the remaining volume is distributed between Egypt and Sudan at the rate of 3:1 according to a 1959 bilateral treaty. Thus, Egypt's share is an average 55.5 BM^3/year. Only about 0.26 $BM^3$of fresh water actually reaches the sea **(Abu-zeid*et al.*,, 1992).**

The current water flow allows for year-round river navigation, even during the period when the water level is lowest.According to the Egyptian national plan, distribution of Nile water use in Egypt for the year 2000-2001 is approximately 67.6 BM^3, comprising of agricultural, industrial and municipal demand of 55.2, 7.6 and 4.5 BM^3, respectively (Table 1). The added 12.1 BM^3 water use over the released water from the Aswan High Dam (67.6-55.5 Bm^3) comes from recycled agricultural drainage water (5.0 BM^3), municipal reused drainage water (0.7 BM^3), ground water (5.4 BM^3) and some rainfall (1.0 BM^3)**(Abdel-Gawad,2002).**

Agriculture consumes nearly 82% of Egypt's share of Nile River. By the year 2017, total water demand in Egypt is estimated at 87.9 BM^3, representing a 30% increase over current consumption. The major contributor to this increase is in the agriculture sector. Egypt is entering into new agricultural development projects to expand the cultivatable area from 7.5 million to 11 million feddan, representing an overall increase of 3.4 million feddan(**Abu-zeid*etal.*, 1992**).