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Recovery of sludge of waste water treatment plant: case study of Guelma station

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ABSTRACT/RESUME

Abstract: *The analysis of metal contamination of Guelma station's sludge has been determined by X-ray fluorescence spectroscopy. It helped to identifythe following constituents: Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Br, Rb, Sr, Y, Zr, Mo, Mg, Cd, Ba, Lu and Pb. These elements represent 47.96% of the total mass of sludge. The indicator elements of pollution existence are: zinc, lead, copper, chromium and nickel. Their content in the sludge treatment plant of Guelma are respectively: 1.61 mg/g, 0.49 mg/g, 0.45 mg/g, 0.18 mg/g and 0.09 mg/g. The assessment of nitrate ions concentration, chemical oxygen demand (COD) and pH was obtained after extraction in aqueous solution. The analysis showed that filtrate contained 0.09 mg/g of nitrate that its COD was 0.72 mg/g and its pH was 7.01.*

I. Introduction

The total volume of wastewater collected in Algeria is around 1.2 billion m^3/year [1], 35% of this volume is treated under biological treatment plants. Other processing pathways have been studied but not yet applied [2]. Purification of wastewater in biological treatment plants generates a large quantity of sludge. These sludges contain nitrogen and phosphorus compounds and organic matter interesting in fertilization. They also contain pathogens [3-7] anddangerous chemical contaminatingforhumanhealthandforenvironment [8, 9]. Metallicelementstraces(MTE)represent the biggest part of these compounds [10].

According to their quality andtheircomposition,sludges of purification canhaveseveral final destinations: agricultural spreading, land filling, incineration and composting [11, 12].Besides these uses, sludge from sewage treatment plants can be used as biosorbent [13, 14], as a means to reduce load losses while dredging operation of hydraulic dams to facilitate the transport of sludge dams in storage location [15] and for biogas production [16]. Elimination cost of sludge from a treatment plant can reach 60% of the operating cost [17]. The use of spreading seems to be the most suitable for means of developing countries. This allows recycling a portion of this sludge and benefit from their fertilizing properties. For this it is very important to characterize the sludge of wastewater treatment plants order to its application in agriculture. The use of sludge contaminated by metal trace elements causes its adsorption in plants and therefore enters food chain. A slightly basic pH and clayey soil have tendency to achieve better control of metal accumulation in plants [18]. The purpose of this work is to characterize sludge from the water treatment plant of Guelma for recovery.

The maximum load for which was designed this station is 200 000 population equivalents [19]. The evaluation of MTE will be made by X-ray fluorescence spectroscopy. That nitrate ions, organic matter and pH will be made after extraction in aqueous phase [10].

II. Materials and methods

The sludge samples were taken from wastewater treatment plant of Guelma. They were used after drying and grinding. XRF has several advantages for the chemical analysis of solid samples [20]. It does not require solubilization of the sample and major and minor components are determined in one analysis. Evaluation of most elements present in the sludge was performed by X-ray fluorescence spectroscopy. The X-ray fluorescence analysis was performed by a spectrophotometer Panalytical Epsilon 3 of a power of 9 watts. Extraction was performed by stirring 10 grams of sludge in 100 ml of UHQ water for one hour. The solution obtained after centrifugation has served for the determination of pH, COD and nitrate ion concentration.

COD determination was performed by energetic oxidation in sulfochromic medium of organic matter. This causes a reduction of the initial concentration of potassium dichromate.

Spectrophotometric dosage of residual oxidant at 425 nm has allowed us to determine the quantity of oxygen required for oxidation of organic matter present in the sample. DCO-meter used is Hach brand 45600 model. Spectrophotometer brand is Hach DF/2000.

Determination of nitrate concentration was carried out after reacting nitrate ions with sodium salicylate to obtain sodium paranitrosalicylate, colored yellow and liable to a spectrophotometric dosage at 420 nm. Measuring optical density was performed by a UV visible spectrophotometer JENWAY 7305. The measurement of pH was performed using a pH meter JENWAY 3505.

III. Results and discussion

The study of the peaks positions in X-ray fluorescence spectra recorded under different conditions has allowed us to identify the following elements: Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Br, Rb, Sr, Y, Zr, Mo, Mg, Cd, Ba, Lu and Pb figure 1, 2, 3 and 4. The intensity of the peaks in X-ray fluorescence spectra is proportional to the concentration of contained elements in sample. The sum of masses of elements identified represents 47.96% of total mass of the sludge.

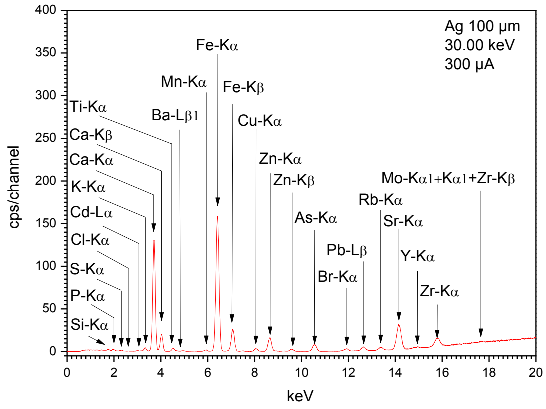

Figure 1. *XRF spectrum of sludge of Guelma wastewater treatment plant achieved with a silver filter of 100 µm, 30.00 kV and 300 µA.*

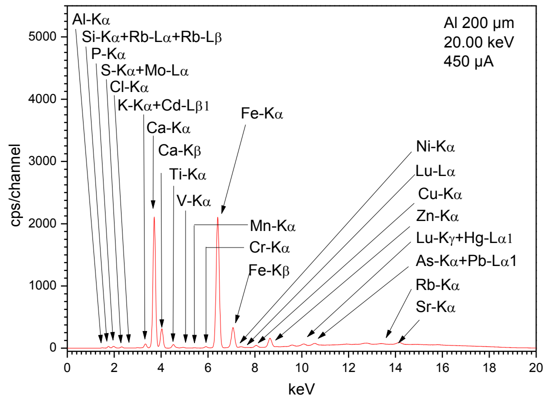

Figure 2. *XRF spectrum of sludge of Guelma wastewater treatment plant achieved with an aluminum filter of 200 µm thickness, 20.00 kV and 450 µA.*

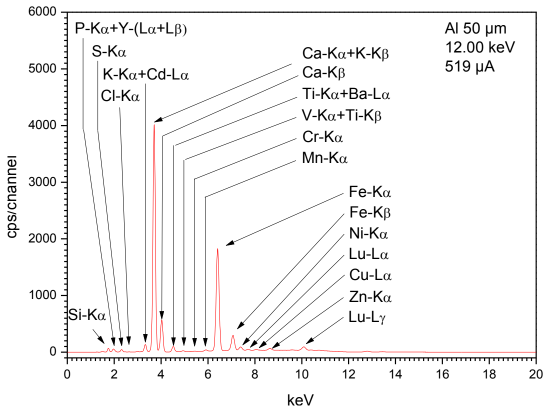

Figure 3. *XRF spectrum of sludge of Guelma wastewater treatment plant achieved with an aluminum filter of 50 µm thickness, 12.00 kV and 519 µA.*

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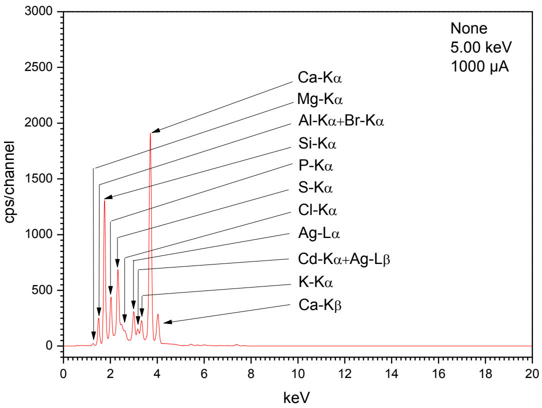

Figure 4. *XRF spectrum of sludge of Guelma wastewater treatment plant achieved without a filter, 5.00 kV and 1000 µA.*

Trace amounts of some heavy metals are required for certain biological processes. Such as copper, iron, cobalt, zinc, vanadium, manganese, chromium, nickel, arsenic, selenium…. They are toxic only if taken in excess or encountered in certain forms [21]. While certain elements in sludge are regarded as pollution. This is a result of their presence in urban effluents [22, 23]. They are not biodegradable and persistent in environment. Their content in sludge is limited by regulations table 2.

The concentration of regulated elements in our sample is shown in table 1. None of these concentrations exceeds the limit allowed by regulation.

Table 1*. Trace elements in sludge from the wastewater treatment plant of Guelma*

Compound	Cd	Cr	Cu	Ni	Pb	Zn	Cr+Cu+Ni+Zn
Concentration (mg/Kg)	1	180	450	90	490	1610	2330

Table 2*. Maximum levels of trace metals in sludge accepted to be spread permitted by the French Regulation [24].*

Trace elements	**Maximum permissible level [mg·kg^{-1} dry matter]**	**Maximum cumulative flow over 10 years [kg/ha/10 years]**
Cd	10*	0.15**
Cr	1000	15
Cu	1000	15
Hg	10	0.15
Ni	200	3
Pb	800	15
Zn	3000	45
Cr+Cu+Ni+Zn	4000	60

* From 1st January 2004; ** from 1st January 2001.

Flow limit authorized for ten years in chrome, copper, nickel, lead and zinc is respectively: 15 kg/ha, 15 kg/ha, 3 kg/ha, 15 kg/ha et 45 kg/ha (Decree of 8 January 1998). Limiting factor in our case is zinc. Its concentration in sludge is 1610 mg/Kg (1.61 Kg/ton). The sludge produced by wastewater treatment plant of Guelma therefore can be used only with an amount less than 27.9 tons/ha on ten years [25]. The treatment plant of Guelma can produce 8.000 tons of sludge per year. Respect for spreading standards allows use that 27.9 tons/ha on ten years. It will be necessary use an area of over 2867 ha for spreading.

Measuring concentration of dissolved nitrate ions has given us a value of 0.09 mg/g (0.09 Kg/ton). If we spread 2.79 tons of sludge per hectare (27.9 tons/ha on ten years), we will bring 0.25 kg of nitrate ions per hectare [26]. COD measurement which gives the quantity of solubleoxidizable matter in the sludge gave a value of 0.72 mg/g (0.72 Kg/ton). This quantity is composed mainly of organic matter. If we spread 2.79 tons of sludge per hectare, we will provide 2.01 Kg of soluble organic material per hectare. The measured pH of sludge from sewage treatment plant Guelma is 7.01, it is inoffensive in their application.

IV. Conclusion

The analysis determined by X-ray fluorescence spectroscopy of the sludge helped to identifythe following constituents: Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Br, Rb, Sr, Y, Zr, Mo, Mg, Cd, Ba and Pb. These elements represent 47.96% of the total mass of sludge. None of these concentrations exceeds the limit allowed by regulation. The limiting factor for spreading in our case is zinc. Its concentration in sludge is 1610 mg/Kg (1.61 Kg/ton). The sludge produced by wastewater treatment plant of Guelma therefore can be used only with an amount less than 27.9 tons/ha on ten years. The treatment plant of Guelma can produce 8.000 tons of sludge per year. It will be necessary use an area of over 2867 ha for spreading.

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