Assess the physical and chemical characteristics and toxicity elements of the sludge of treatment plant: Minireview

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This review is a survey on the latest and more recent applications of physical and chemical analyses to study different changes that plants undergo when using sludge as a fertilizer. Although sewage sludge is regarded today as waste by the new regulations, it has a real agronomic interest because of the presence of organic matter, nitrogen, phosphorus and a favorable carbon / nitrogen ratio. But to value the sludge must both respect the environment; look at the lowest cost possible and the most satisfactory technical solution.

This chapter covers recent trends in using sludge as natural fertilizer on field crops such as cereals and vegetable crops, then the sludge samples have been subjected to physical and chemical analyses such as: Hydrogen potential (pH), Electrical conductivity (EC), Organic matter (OM), total limestone / active Limestone, granulometry, humidity, cations exchange capacity (C.E.C)…

Keywords: physical and chemical; sludge; environment; fertilizer; pH

1. Introduction

The composition of the sludge varies considerably depending on the origin of the wastewater entering the treatment plant. Such wastewater may be of domestic, industrial or commercial origin; Or from urban stream. The composition of the sludge varies, depending on the respective share of each of these inputs.

According to Vergès (1984), the average value of sludge production is 50 grams of dry matter per person per day, representing a volume of 1 to 2 liters of liquid sludge per person per day.

Sewage treatment plant sludge (STEP) contains not only macro-elements (nitrogen, phosphorus) and organic matter generally used for soil remediation, but also contains 2 kinds of undesirable elements, because potentially dangerous for humans, animals or the environment: these are pathogens and chemical contaminants.

The main objective of the treatment of sludge in the treatment plant is to reduce the volume of the sludge in order to limit the quantities to be stored (or even spread) and to stabilize them in order to improve their physical characteristics (Improvement of their heap content) and to stop the biodegradation of which they are the center. Indeed, their high water content (99%) and the strong bacterial populations that are found there make it a culture broth favorable to the degradation of the fresh and fermentable organic matter that they contain, producing bad odors.

It has an impact on the growth and development of potato, tomatoes, and wheat. It has an objective:

- Assess the physical and chemical characteristics and toxicity of the sludge in treatment plant.

2. Conducting the analytical work

After removing the sludge from a sewage treatment plant and before starting the necessary analyzes, the steps to be taken are:

2.1 Sample drying

Sludge samples should be dried in a dry place at room temperature and then in an oven at 105 ° C for 24 hours.

Fig. 1 Sludge used (shot of Bouslimani and Benzara, 2015).

2.2 Sifting

The sludge must be screened with a 2-mm sieve.

2.3 Physico-chemical analyzes

The main analyzes carried out on our sludge are summarized in the table below

Table 1 Summary table of laboratory analysis measurements.

Parameters measured	Methods for measuring analyzes
Hydrogen potential (pH)	Dilute extract (1 / 2.5); pH meter
Electrical conductivity (CE)	Dilute extract (1/5); Conductimeter
Organic matter (M.O)	ANNE method
Total limestone / Active limestone	Calcimeter of BERNARD DROVINEAN
Granulometry	Method of STOCKES (by ROBINSON pipette)
Humidity	Drying in an oven at 105 ° C.
The cation exchange capacity (C.E.C)	Metson

2.3.1 Hydrogen potential (pH)

By definition, it is the unit of measurement of the concentration of hydrogen ions, which makes it possible to evaluate the acidity or the basicity of a medium; it defines the concentration of H + ions in the liquid phase of the soil [1]. Indeed, the pH varies from 0 to 14 and the neutrality is reached when the pH is equal to 7.

Table 2 pH Interpretation Scales: Extract 1 / 2.5 [2].

pH ≤5.5	Strongly acid
5.5<pH≤6.0	Frankly acid
6.0<pH≤6.5	Slightly acidic
6.5<pH≤7.0	Neutral
7.0<pH≤7.5	Slightly alkaline or slightly basic
pH>7.5	Alkaline or basic

There are several methods for measuring pH, the most accurate method for measuring the pH of a soil is to use an electrical "pH meter" which directly gives the pH value when immersing glass electrodes in a solution obtained in Mixing one part of soil sample with two parts of distilled water [3].

Sewage sludge should be mixed with lime (preferably quicklime rather than hydrated lime) in order to raise their pH to 12 and thus prevent the survival of potentially pathogenic microorganisms. This treatment of sewage sludge also makes it possible to increase the dryness of the sludge (dry matter content) because the quicklime reacts exothermically when in contact with the water contained in the sludge and steam is released.

A30% dryness is easily obtained whatever the dehydration equipment used. The mud / quicklime mixture should be as homogeneous and intimate as possible so that each lime grain is well reacted, allowing optimum yield [4].

According to [5], pH is a major factor in the retention of heavy metals because it controls all the processes affecting the behavior of these elements. The variation of the pH (natural in anthropic) seems to be the factor whose action has the most determining on the mobility of metals. Most trace metallic elements are more mobile under acidic conditions than under alkaline conditions [6].

The average pH for the sludge is in the range of 9.84 and 7.97, slightly alkaline to alkaline, so it is relatively favorable to all species.

2.3.2 Humidity

Field moisture corresponds to the moisture content of a soil sample at a given time; in particular at the time the sample was expressed as a percentage, moisture is obtained by weight difference in the sample after desiccation at 105 ° C for 48 hours.

Indeed, at the output of waste water treatment, the water content of the sludge is around 99% of the crude material. Reducing the masses to be handled by avoiding dust and improving quality are the issues involved in the recycling and recovery of sewage sludge. The processing proceeds by reducing the water content of sludge, in particular through drying.

In evaporating, the sludge loses all or part of their water and become solid.

The drying bed technique is practiced in open air on liquid sludge and combines natural evaporation and drainage of the free water through a filtering layer of sand and gravel.

This extensive system, depending on the weather conditions, produces solid sludge at 35 - 40% dryness [7].

2.3.3 Electric conductivity

This physicochemical measure gives us an idea of the concentration of the electrolytes in the soil solution on the one hand and the degree of salinization of the soil on the other hand.

The electrical conductivity with diluted extract (extract 1/5) is the salinity rate in the ratio of the quantity of soil to the quantity of water required for the preparation of the extract [8].

For the calibration of the apparatus: the Kcl (0.02N) is placed in the oven and the temperature is measured up to 25ºC.

Table 3 Classification of electrical conductivity [9].

Electrical conductivity (ms / cm)	Designation
<2.5	Unsalted
2.5-5	Low salt
5-10	Moderately salty
10-15	Dirty
15-20	Highly salty
20 to 27.5	Very strongly salted
>40	Hyper sale

For our sampled sludge, the electrical conductivity values range from 7.31 mS / cm to 7.08 mS / cm, so our sludge is part of the average salt class, Therefore, our sludge is part of the average salt class. On the other hand, excessive salinity of the sludge can cause damage to soils and plants.

2.3.4 Determination of Organic matter (ANNE method)

Organic matter is determined by means of organic carbon, taking as a fact that organic carbon accounts for 58% of the organic matter, using the ANNE method (1945). It consists of calculating:

$$\%C = \left(V_{control} - V_{sample}\right) \times 0.615/P \quad \text{.....(1)}$$

With:

P: soil weight is 1 gram.

$$MO = \%C \times 1.72 \quad \text{.....(2)}$$

Table 4 Classification of organic matter according to [10].

Type of soil	Organic material (OM) (%)
Very poor	< 14
Poor	14 ≤ OM < 20
Moderately poor	20 ≤ OM< 30
Rich	30 ≤ OM< 40
Very rich	OM ≥ 40

Generally, the sludge is rich in organic matter and contains nutrients (N, P, K and trace elements). These elements are useful for the good development of crops.

- Nitrogen (N) plays a major role in plant metabolism as a major component of proteins. It is essential for the growth of plants.
- Phosphorus (P) transports energy to the plant. It promotes the general growth of the plant, especially the root and the stems system. At the end of vegetation, it is stored in the storage organs to serve the development of future growth
- Potassium (K) enhances crop resistance to disease, drought and frost.

The trace elements (Copper, Magnesium, Zinc, etc.) are useful in reduced quantity to carry out all the chemical reactions that take place in the plant [11].

Indeed, according to AFNOR standards, the results of our sludge show that it is very rich in organic matter where the rates exceed 65%.

2.3.5 Determination of total limestone (BERNARD Calcemeters)

According to Aubert (1978), the evolution of limestone in our sludge must be monitored from the measurement of CO_2 evolution in BERNARD Calcimetre, and therefore by gasometry, this dosage is based on the characteristic reaction of calcium carbonate and Hydrochloric acid:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2 \quad \text{.....(3)}$$

It is a question of comparing the volume of CO_2 released by the contact of HCL with a precise weight of sludge with that released by the contact of HCL with the pure and dry $CaCO_3$ in a known amount. The temperature and pressure conditions remain unchanged.

In addition, the presence of limestone plays an important role in ionic equilibria, particularly in pH values, and the limestone content is related to the nature of the substrate or to the different artificial inputs to correct the pH of the soil and to increase the buffer capacity of these studied soils [12].

2.3.6 Granulometry (ROBINSON pipette)

The purpose of granulometric analysis is to determine the texture of the soil by classifying the mineral particles constituting the soil sample by diameter category. The particles are separated by soil analyzes into three distinct classes: sand (2 to 0.05 mm), silt (0.05 to 0.02 mm) and clay (less than 0.02 mm) [13]. This allows us to know certain characteristics of the soil, such as the ability of roots to penetrate it, the capacity of the soil to retain water, or its vulnerability to compaction [14]; and therefore, the particle size distribution is carried out according to the international method which is based on the STOCKES law, which gives the settling velocity of a spherical particle in a liquid as a function of the diameter of the particle. This method uses the ROBINSON pipette, the texture is determined by a textural triangle. The removal of clays and fine silt was carried out using the Robinson pipette; the fine and coarse sands were recovered by sieving, the coarse silts were deducted by the difference [15].

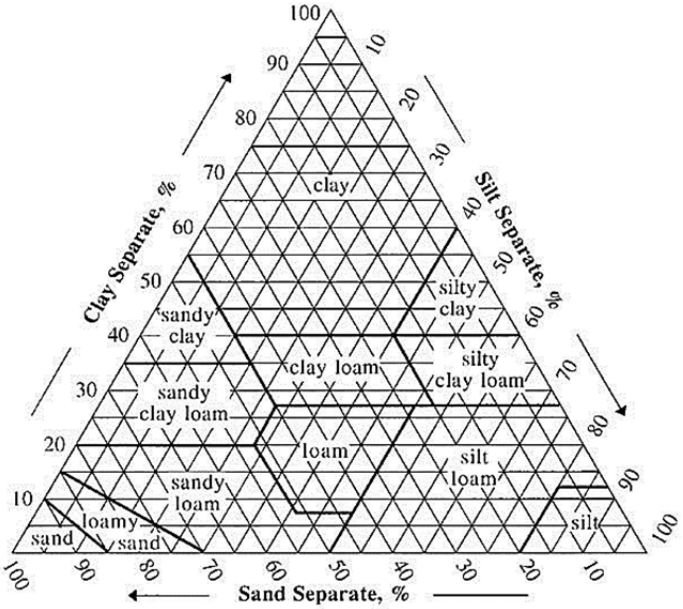

Fig. 2 Textural Triangle (American (USDA) triangle) [16].

The granulometry distribution of sludge is difficult and time-consuming to measure. The rare measurements carried out also show a strong dispersion around the mean diameter. On the other hand, if size is generally a favorable criterion, particles of large size can lead to problems with conveying (deposits) or abrasion (silica), especially in the case of centrifugation [17]**.**

According to the results, the sludge used in our experiment are made of: 20% clay, 5% silt, and 75% sand for our sludge.

If we compare these results to the US textural triangle (USA), we can conclude that our sludge has a Silty-sandy loam texture and according to [18], the texture obtained for sludge is middle class.

2.4 Nutrient Supply

However, the sludge contains some elements useful for plant growth, nitrogen, phosphorus, potassium and magnesium. The quantities vary from one sludge to another according to the origin and the mode of treatment [19]**.**

The crops most favored by the presence of nitrogen appear to be grass and corn, followed by cereals [20].

Phosphorus existing in less quantity than nitrogen.

As for the other three elements: potassium, calcium and magnesium, plants use them as oligo elements more than they use them as elements of development.

2.5 The mineral micropollutants

These are essentially what are called heavy metals, which have been extensively studied in the laboratory and in the field for their role in the development of irrigated crops by liquid or non-liquid sludge [21]**.**

Some of these elements are found naturally in the soil such as copper, iron, zinc ... and are essential to the growth of plants, while others are added by man and can have unfortunate consequences [22]**.**

2.6 The toxic elements

Indeed, these elements are not used by the plant for its development but can accumulate in it by accumulation [23]**.**

- **Aluminum**: is slightly soluble at pH close to neutrality and its content in plants is very variable. It becomes important for plants that grow in wet conditions. The toxicity of aluminum has not been demonstrated either for mammals or for humans [24]**.**
- **Arsenic**: As a salt, arsenic is as toxic to plants as it is to animals and man (arsenate or arsenite), but it seems that in organic form it is less dangerous. The inputs of this element come mainly from pesticides and very little sludge [25]**.**
- **Cadmium**: is brought into the soil by the atmosphere (rain), leaching of roads and sewage or sludge containing electroplating effluents. It is certainly the most studied micro pollutant in the case of sludge spreading because it is assimilated by plants and accumulated by mammals and humans (the quantity tolerable for humans is 0.3 ppm day). Cadmium is not very toxic to plants (especially leaves) and stored quantities depend on soil pH [26]**.**
- **Chromium**: is considered a toxic to humans and animals. Chromium is often found in sludge, but it seems to be transformed into the soil into sparingly soluble elements which cannot be easily assimilated. Tests of the addition of large quantities of chromium to the soil have shown that it has no disadvantages for plant yield [27]**.**
- **Mercury:** is an important toxicant for humans and animals, found in soil from insecticide application, rainwater and runoff, and sludge spreading. Floor. When the soil pH is above 6.5 mercury appears as a poorly soluble hydroxide or carbonate.
- Mercury can cause disturbances to the development of the plant, but the main danger is then its introduction into the human food chain because it is organic accumulated by the animals, but there does not seem to be any preferential accumulation in one part of the plant as has been seen for cadmium [28]**.**
- **Nickel:** present in industrial fumes and wastewater is found in soil by rainwater or sludge. The action of nickel alone on plants is known, it seems that a concentration of 1 p.p.m is enough to disrupt the growth of the plant [29]**.**
- **Lead:** The presence of lead in the soil leads to an accumulation on the surface layer. The origin of the lead is essentially atmospheric since a large part comes from the exhaust of cars. It enters the plant through the roots when it is in the soil and by the leaves when it is in the atmosphere but its presence does not seem to disrupt the development of the plant [30]**.**

In summary, it may indicate that some micro-pollutants are harmful to plants whether they promote withering, or they do lower the productivity and others are harmful to plants and consumers as they can be dangerous to human due to bioaccumulation. Their presence in sludge is rarely the only source but it is an additional risk that man brings to the level of agricultural production [31]**.**

3. Conclusion

A wastewater treatment plant exists to protect the surrounding environment including water resources. Sewage sludge has useful agronomic properties in the field of agriculture. Their use must take into account the nutritional needs of the plants without compromising the quality of the soils or that of the surface and ground waters. Indeed, some heavy metals in sewage sludge can be toxic to plants and humans.

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