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# Stabilization in an Alkaline Treatment Plant Domestic Wastewater: Experimentation and Physico-Chemical Characterization of Biosolids

[1]Reyes Juan Pablo, [1]Guarnizo Pizza, [2]Carlos Andres, [1]Rodriguez Miranda and [2]Juan Pablo
[1]Department of Biotechnological Production Water and Environment Sanitation, Universidad Manuela Beltran, Bogota, Colombia
[2]Department of Sanitary and Environmental Engineer, Universidad Distrital Francisco Jose de Caldas, Director of the Research Group AQUAFORMAT, Carrera 5 Este No. 15-82, Avenida Circunvalar Venado de Oro, Bogota D.C. Colombia

**Abstract:** This study presents the evaluation of the alkaline stabilization of the biosolids results of the operation of a treatment plant of wastewater to improve the fisiochemical quality. Two alkalizing, the alive cal (CaO) and the hydratedcal ($Ca(OH)_2$), characterizing two experiments, each one form by dose of 15 and 25% in proportions weight to weight of biosolid duplicated with a treatment witness without application of alkalizing, totalizing ten treatments. The treatment of biosolid with dose of 15% of hydratedcal ($Ca(OH)_2$), accomplishing the previous period of dryness in a month, got better results according not to modifying drastically the content of organic matter and macronutrients (N, P and K) and accomplishing the maximum values of humidity.

**Key words:** Biosolids, stabilization, wastewater, hydratedcal, fisiochemical

## INTRODUCTION

The biosolids are consider as an importat source of nutrients as Nitrogen (N) and Phosphorous (P) and according with Jesus *et al.* (2007) could have concentrations of chemical substances consider toxic like heavy metals (Arsenic, cadmium, chromium copper, mercury, nickel, lead, selenium and zinc); concentrations that depend on the nature of downloads made to the sewer system (Patricia *et al*., 2009). The increase of reuse of biosolids with beneficial purposes in the agriculture make people worry about the possible contamination of hydric resources and the food chain.

The infections for helminth are the main concern in developing countries that do not dispose accurately the sludge (Sidhu and Toze, 2009). The concentration of microrganisms pathogens and parasites in the biosolid has a relation with factors with conditions socio-economics, sanitary and the health of population, the region, the presence of animals and the type of treatment that the slurry was subjected. According to this a wrong application in the land could affect negatively to the human and animal health, the quality of the land, the growing of the plants and contaminate the underground water and superficial (US EPA, 2000). One of the alternatives to the final disposal of biosolids is to use as helpers of the agricultural lands, because those are a sourse of nutrientsfor crops for their content of organic matter, macronutrients like N, P and K, some macronutrients like Cu and Zn (Silveira *et al*., 2003). Although, they have less amount of nutrients that the commercial fertilizers (for nitrogen, phosphorus and potassium, respectively) can be used to replace part or all the commercial fertilizers that are in use. It is also seen that the biosolids have properties that make them superior to the fertilizers, cause have properties of coagulation, water retention and the continuous slow release of nutrients so ones stabilized, these could be use as fertilizers that improve the land or cover of landfills. But it is not official the national rule that coordinate the secure application of this product and allows incorporate it to the economical productive cycle and to the environmental programs that could be use to reduce the desertification of soils.

This study consider the evaluation of the alkaline stabilization of the biosolids generated in the Wastewater Treatment Plant (WTP) of the village of La Calera (Cundinamarca, Colombia), operated by the Regional Autonomous Corporation of Cundinamarca (CAR) to improve the quality physical and chemical quality, using Cal alive (CV) and Hydratedcal (CH) in combination with biosolid of 15 and 25% in proportions of weight to weight.

## MATERIALS AND METHODS

The research applied was almost experimental, cause studied relations cause and effect in conditions of rigorous control of the factors that could affect the experiment of alkaline evaluation (Baltazar, 2000) also

**Corresponding Author:** Reyes Juan Pablo, Department of Biotechnological Production Water and Environment Sanitation, Universidad Manuela Beltran, Bogota, Colombia

Table 1: Preliminary characterization of bio solids

| Parameter | Results | Analytic method |
|---|---|---|
| **Fisicos** | | |
| Total solids (mg-ST/L) | 1.53 | Secado a 103-105°C (2540 B) |
| Temperature (°C) | 13.50 | Termómetro de punzón |
| pH | 7.30 | Electrométrico |

according to the time of occurrence of the facts and the register of the information related with the topic of study, the type of research applied was also consider as descriptive, cause allowed to describe some fundamental characteristics of the homogeneous phenomenon (Carolina, 2010).

**Population and sample:** The research was developed with biosolids of the drying beds of the WTP of the village of La Calera, Cundinamarca (Colombia) and the biosolids were taken from the drying bed N°11, when it finishes the dry cycle of 30 day. To the development of the studio it was taken a sample that came from the drying bed N°11 at the beginning and each unit research at the end randomly by a deep of 8 cm approximately.

To the alkaline treatment of biosolid there were evaluated two alkalizing, the cal alive (CaO) and the hydratedcal ($Ca(OH)_2$), characterized two experiments, each with a consisting dose of 15 and 25% in proportions weight to weight of biosolid duplicate with a control treatment without application of alkalizing, totalizing ten treatments. The development of the research had three periods: the first, the preliminary characterization of the biosolid, the second, the execution of limed biosolids field according to the dose already proposed and the third about the programing and take of samples to the analysis in situ and the laboratory along the time of study that will be 13 day. According to the methods consider in Table 1 and according the standard and la actual Norma 40 CFR Part 503 (US EPA, 1993) with the propose to know the parameters physiochemical, like this.

## RESULTS AND DISCUSSION

The information base of characterization physiochemical of sludge generated in the treatment plant of residual water, exposed in Table 2, consider the content of heavy metals in the mud. Table 3 show the results of the physiochemical analysis that took the biosolids used in the studio. According to this we can see that the biosolid has a pH of 7.1 units, considering as neutral that indicates that it does not show any problem so be subjected to the treatments with cal alive and hydrated while the chemical parameters present concentrations of 1.50, 1.30 and 0.23% of total nitrogen of total phosphorus and potassium, respectively values very near to the typical ranges in Colombia (Maria, 2006). According to the oxidizable organic carbon total the concentration

Table 2: Content of heavy metals in the biosolid. WTP the Calera metales pesados

| Mateles pesados | | | | |
|---|---|---|---|---|
| Parameters (μg $L^{-1}$ (ppb)) | VMD[a] | Permissive limit | Results | Analytic method |
| Arsenic | 1,000 | 5000 | <VMD | ICP –MS (EPA 200.8) |
| Barium | 1,500 | 100000 | 264 | ICP –MS (EPA 200.8) |
| Cadmium | 0,500 | 1000 | <VMD | ICP –MS (EPA 200.8) |
| total chromium | 0,500 | 5000 | 16,75 | ICP –MS (EPA 200.8) |
| Mercury | 1,500 | 200 | <VMD | ICP –MS (EPA 200.8) |
| Silver | 0,200 | 5000 | <VMD | ICP –MS (EPA 200.8) |
| Lead | 0,400 | 5000 | <VMD | ICP –MS (EPA 200.8) |
| Selenium | 10,000 | 1000 | <VMD | ICP –MS (EPA 200.8) |

[a]VMD: Minimum detectable value

Table 3: Characteristics of biosolid used in the current studio, pretreatment

| Parameter/units | Result | Method |
|---|---|---|
| **Physical and chemical** | | |
| Temperature (°C) | 17 | Termometro de punzon |
| pH | 7.1 | Electrometrico |
| Humidity (%) | 28.7 | Secado a 70°C/24 h |
| C.O. Total oxidizable (%) | 11.9 | Walkley-Black (colorimetrico) |
| Total Nitrogen (%) | 1.50 | Micro-Kjeldahl (volumetrico) |
| Relation C/N (%) | 7.89 | |
| Total Phosphurus (%) | 1.30 | Calcinacion a 475°C (Colorimetrico) |
| Calcium (Ca) (%) | 1.02 | Calcinacion a 475°C |
| Potassium (K) (%) | 0.23 | Calcinacion a 475°C |
| magnesium(Mg) (%) | 0.16 | Calcinacion a 475°C |
| C.I.C. (meq 100 $g^{-1}$) | 37.7 | Volumetrico |
| Electrical conductivity (dS $m^{-1}$) | 4.60 | Conductivimetro a 25°C |
| Iron (Fe) (mg $kg^{-1}$) | 14491 | Calcinacion a 475°C |
| Copper (Cu) (mg $kg^{-1}$) | 28,8 | Calcinacion a 475°C |
| Manganese (Mn) (mg $kg^{-1}$) | 97.0 | Calcinacion a 475°C |
| Zinc (Zn) (mg $kg^{-1}$ | 780 | Calcinacion a 475°C |
| Boron (B) (mg $kg^{-1}$) | 52.6 | Calcinacion a 475°C |

of 11.9% is relatively near to 15% recomended to ICONTEC and according to the Agency of L'environnement et de la Maitrise de L'energie, the relation C/N is in the range for biosolids of PTAR.

Table 3 shows the summary of the quartiles Data analysis of pH and Fig. 1 shows the diagram of the box (boxplot) to the treatment In general terms the biosolid present a pH tipical average of 6.91 units; ones the treatment with cal, the pH of biosolid increase significantly to 12.2 units in 2 h. Figure 1 shows that although the type and dose of cal, there is a similar behaviour of the manteinance of the values of pH over the 12 units; according to the reports by several researcher (US EPA, 1993; Haandel and Sobrinho, 2006), even till the day 13; accomplishing much the recommendation by US EPA (1994) to the reduction of pathogens (Table 4 and 5).

Table 6 presents the maximum values and the temperature increase for each treatment. We can see that in the treatments with cal alive and hydrated we get an increase of the temperature between 4 and 6°C, the dose of 15% CaO has the greater increase, result relatively

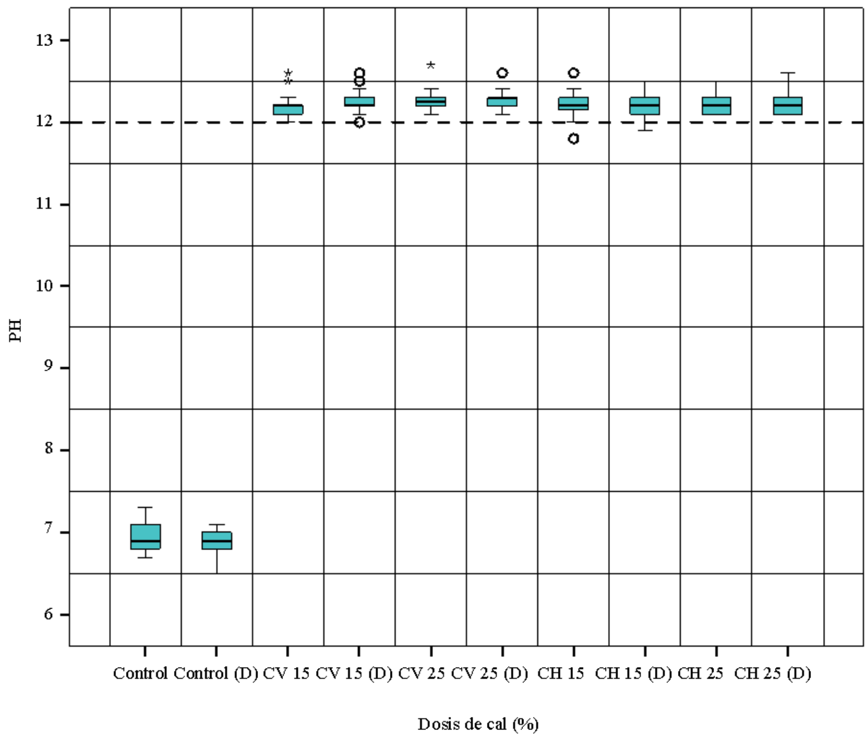


Fig. 1: Diagram of boxes and wires of the variation of pH during the 13 day of experimentation

Table 4: Summary of quartils

| Treament | Q1:25% | Q2: median | Q3: 75% |
|---|---|---|---|
| Control | 6.8 | 6.9 | 7.1 |
| Control (D) | 6.8 | 6.9 | 7.0 |
| 15% cal alive | 12.1 | 12.2 | 12.2 |
| 15% cal alive (D) | 12.2 | 12.2 | 12.3 |
| 25% cal alive | 12.2 | 12.2 | 12.3 |
| 25%cal alive (D) | 12.2 | 12.3 | 12.3 |
| 15% cal hydrated | 12.1 | 12.2 | 12.3 |
| 15% cal hydrated (D) | 12.1 | 12.2 | 12.3 |
| 25% cal hydrated | 12.1 | 12.2 | 12.3 |
| 25% cal hydrated (D) | 12.1 | 12.2 | 12.3 |

Table 5: Tendency of the temperature in the treatments

| Type of cal | Dose (%) | Maximum temperature (°C) | Increase (°C) |
|---|---|---|---|
| Control | 0 | 20 | 3 |
| Cal alive | 15 | 23 | 6 |
| Cal alive | 25 | 21.5 | 4.5 |
| Cal hydrated | 15 | 22 | 5 |
| Cal hydrated | 25 | 21 | 4 |

Table 6: Values of humidity (%) got in the biosolids with different dose of CaO and $Ca(OH)_2$

| Type of alkalinizer | Dose (%) | Day 0 | Day 13 | Loss of humidity (%) |
|---|---|---|---|---|
| Control | 0 | 28.7 | 26.8 | 6.6 |
| CaO | 15 | 28.7 | 19.1 | 33.4 |
| | 25 | 28.7 | 20.6 | 28.2 |
| Control | 0 | 28.7 | 26.8 | 6.6 |
| | 15 | 28.7 | 17.6 | 38.7 |
| $Ca(OH)_2$ | 25 | 28.7 | 16.5 | 42.5 |

similar to the studio by Cadiergues *et al*. (2001) we got increase of 9°C in the mud but with the higher dose of CaO of 45%; however this result could be consider like insignificant compared to the control treatment because the low content of humidity of biosolid, cause finished the drying cycle of 30 day, also like Haandel and Sobrinho (2006) to the experimental conditions like the mixture, the type of mixer and the storage of the cal already used (Hydration degree).

According to Table 7 is clear that the biosolid has a humidity of 28.7% which presents a little reduction in the witness at the end of the studio with a value of dryness of 6.6%, this data is not weird cause the previous dehydration of biosolid during a month, this reduces a lot the level of the water. This is also reported by Sperling and Marcos (2005) in studios that showed the efficacy in the natural dryness of mud in courtyards, in Brasilia and got values of 86-25% of humidity in a period of 30 day in several studios we saw the influence of the weather and the season of the year in the reduction of the humidity and the big reduction of eggs of helminto in mud in the south, southeast and northeast of Brasil. In the treatments of cal got values between 16 and 21%, presenting the treatment with the dose of 25% of cal hydrated a clear reduction of humidity (16.5%), this is equivalent to a dryness of 43%. According to the final humidity values

Table 7: Values of the agrologic characteristics final of the biosolid

| Treatment | Dose (%) | C.O. Oxidable total (%) | Organic matter (%) | Nitrogen (%) | Phosphorus (%) | Potassium (%) |
|---|---|---|---|---|---|---|
| Contro | 0 | 18.70 | 32.2 | 2.67 | 1.57 | 0.29 |
| CaO | 15 | 10.90 | 18.8 | 1.11 | 1.34 | 0.24 |
| | 25 | 7.89 | 13.6 | 0.65 | 1.05 | 0.23 |
| $Ca(OH)_2$ | 15 | 1.20 | 9.3 | 0.17 | 1.40 | 0.19 |
| | 25 | 8.01 | 13.8 | 0.81 | 0.29 | 0.17 |

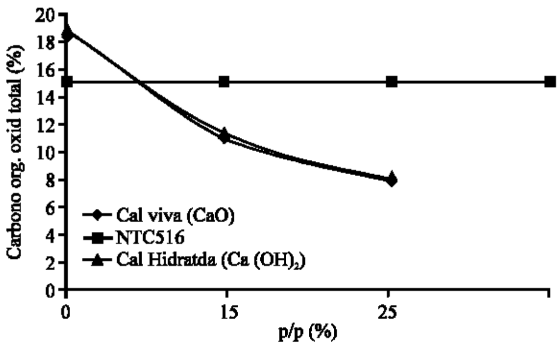


Fig. 2: Concentration of C.O. total oxidizable in the biosolid treated with different dose of CaO and $Ca(OH)_2$

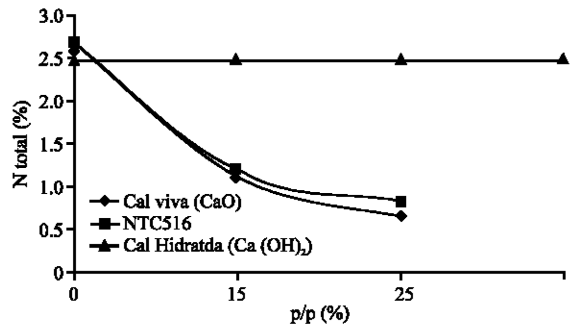


Fig. 3: Concentration of the total nitrogen treated with different dose of CaO and $Ca(OH)_2$

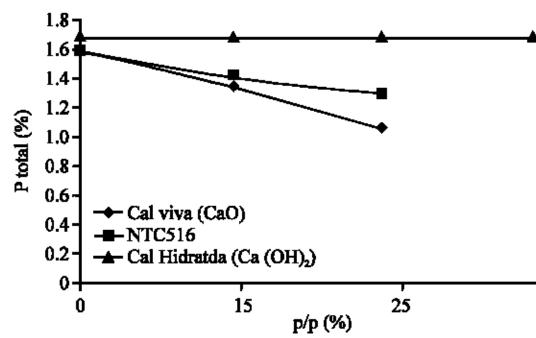


Fig. 4: Concentration of total phosphorus in the biosolid treated with different dose of CaO and $Ca(OH)_2$

of each treatment we can say that accomplish the maximum values recommended by the NTC 5167 of 35% in plant fertilizers and 20% in animal fertilizers.

According to the evidence in Table 8 the biosolid presented low percentages of oxidizable organic carbon and organic matter, like the nutrients said the control. The previous concentration of total oxidizable organic carbon of the biosolidwith out treatment presents a value that accomplish the exigence by the NTC 5167 but as well as we see in Fig. 2, the stabilization with CaO and $Ca(OH)_2$ presented a reduction to the concentration every time the dose increase as a result it got low values demanded by the rule but it is important that the dose with 15% of the two alkalinizers has the lowest effect on this reduction. According to the first content of organic matter (M.O.) the biosolid presents a value of 32.2 % (calculated according to the content of COT) that after the stabilization it reduced to 18.8 and 19.3% with a dose of 15% of CaO and $Ca(OH)_2$, respectively but according to Lue-Hing *et al.* (1998) the value of M.O. is very high for a cold weather. According to this is important that the main effects of the organic matter over the physical qualities in the land is associated to the association grade as a consequence affects the density, porosity, aeration and the capacity of retention and water infiltration, atributes that surely could guaranty the biosolid obtained. The concentrations of the total Nitrogen were reduced when the dose of alkalinizer increase, said Lue-Hing *et al.* (1998) because the increase of the pH of biosolid, this produces that the ionized ammonia nitrogen ($NH_4^+$) became to gas $NH_3$ and volatize (source of odors). Figure 3 presents the reduction of the concentrations obtained were 1.17% NTK and 1.11% NTK with a dose of 15% de $Ca(OH)_2$ and CaO, respectively although, they are lower the average but very near to the mimimun 1.6% for Colombia, there was a reduction of the concentrations of 56.2 and 58.4%, respectively this is not a limiting cause to the possible use of the biosolid as the soil conditioner.

Figure 4 shows the concentrations of the total phosphorus present during the stabilization, we observe that the initial concentration of the biosolid was of 1.57%, this is a little bit low to the typical average range for biosolids in Colombia, every time increase the dose of alkalinazers show a loss in the concentration, values of 1.4 and 1.29% for the dose of 15 and 25% of the Cal hydrated, respectively and 1.34 and 1.05% with dose of 15 and 25% of Cal alive, respectively this behaviour is signed by Mendez *et al.* (2002) is expected for the neutral

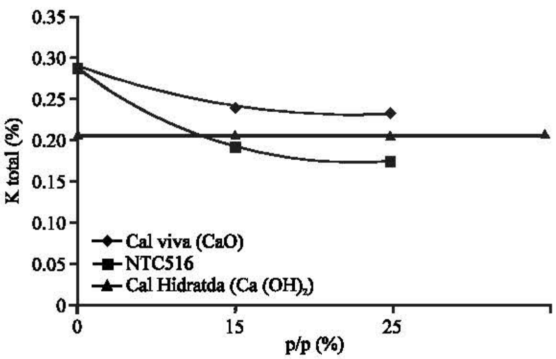


Fig. 5: Concentration of the total potasiumin the biosolid with different dose of CaO and $Ca(OH)_2$

conditions to alkaline the phosphorus is fixed for the Ca, creating forming calcium phosphates which make it mineralize and precipitate.

According to Fig. 5, we can see that the initial concentration of total potassium of the biosolid (0.29%), overcomes the typical average range for biosolids in Colombia; finally we can see that even the treatment with CaO was a reduction of the concentration was not good as the results obtained with $Ca(OH)_2$ and also keeps the content of the total potassium.

## CONCLUSION

The estabilization with calcium oxide (CaO) and calcium hydroxide $Ca(OH)_2$ are the alternatives of viable sanitization of the biosolids of a process of aerobic digestion, because it makes them biosolid type A according to the indicators of fecal contamination evaluated, according to the rule 40 CFR Part 503 (US EPA, 1993) and make them usefull for the agriculture. The biosolids of the aerobic digestion do not have pices of heavy metals, so they does not represent any problem of public health and environmental to reuse, equal to Haandel and Sobrinho (2006) and Ingallinella *et al.* (2002) in the concentration of mud and biosolids of PTAR are lower. During the alkaline estabilization we define that the both types of cal used, could go up and keep the pH of the mixture in superior values of 12 units during the time of study, helping the Inactivation of indicators of fecal contamination evaluated (coli and eggs of helminth) even without accomplishing with the temperature recommended, this alkaline condition possible hlelps the disinfectant power of armonic gas ($NH_3$) obtained from the conversion of the ion $NH_4^+$.

The biosolid treatment wih dose of 15% of hydrated cal $Ca(OH)_2$, accomplishing a previous period of dryness in a month, got better results about modifying drastically the content of the organic matter and macronutrients (N, P and K) and accomplishing with the maximum values of humidity recommended for organic amendments for the NTC 5167 del ICONTEC. Although, the alkaline establizationis a process that stabilizes the organic matter producing biosolids with a content of nutrients that make it suitable for a reuse as soil conditioner presents a disadvantage that increases the concentration of the total soils and high values of pH that limit the use in the soil with problems of alkalinity, however improve the characteristics of the acid soil and reported in the studios.

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