The Influence Mechanism of Class Identification and Environmental Values on Garbage Classification Behavior

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Abstract. The current thermal measurement of sewage sludge in urban sewage treatment plants is mainly based on the determination method of coal calorific value. The calorific value of a secondary sewage treatment plant in a city was measured by an automatic calorimeter. The high calorific value of the sample is obtained by referring to the calorific value measuring method of coal. The results show that the sludge drying base heat value in the process section is relatively high, basically all above 12kJ/g. The theoretical analysis of the calorific value of the same batch of samples is in good agreement with the measured results.

Keywords: Wastewater; sludge; heat value determination; bomb calorimeter

1. Introduction
The biological treatment of sewage contains material changes and energy conversion, and there are a large number of chemical kinetics, biochemistry and thermodynamic phenomena, which have the basic characteristics of thermodynamic research objects [1]. A large amount of excess sludge will be produced during the biological treatment of sewage. These sludges have high organic content, and thermodynamic systems need to be described by thermodynamic parameters such as temperature, pressure, volume, enthalpy and entropy. The pollutant energy value is the basic thermodynamic index. It can reflect the energy level of sewage sludge in all aspects of sewage biological treatment system and the composition of energy of the whole system. The research on its testing method is the basic work of thermodynamic analysis of wastewater biological treatment [2].

At present, the analysis of the calorific value of the sewage from municipal sewage treatment plants is usually based on the purpose of sludge incineration and energy utilization [3]. Less used to study the thermal effects of sewage biochemical reactions. At present, the determination of the calorific value of sewage sludge mainly refers to the method of measuring the calorific value of coal - the oxygen bomb calorimeter method. Since sludge and coal are essentially different, the measurement conditions need to be optimized to obtain more accurate measurement results[4].The use of oxygen bomb calorimeter can obtain more accurate values, but domestic and foreign researchers use it to measure the calorific value of sludge, there are big differences in the specific operation methods such as sample pretreatment and addition of combustion improver, so the combustion The standardization and systematization of calorific value determination is also a subject that needs further study[5].
Therefore, the purpose of this study is to study the conditions in the determination of sewage sludge calorific value. Verify the reliability of the measured method by performing theoretical calorific value calculation on the elemental analysis results of the same sample. Establish an indicator basis for thermodynamic studies of the entire wastewater treatment system.

2. Materials and methods

2.1. Measurement principle and instrument
The calorific value of sewage sludge was measured with an oxygen bomb calorimeter (IKA C2000, Germany) [6]. Put a certain amount of the substance to be tested into the oxygen bomb. Completely burned under conditions of excess oxygen, Measuring the temperature change of the medium before and after combustion. The heat of combustion of the measured substance can be calculated from the change in temperature and the specific heat of the measured medium. The heat capacity of the oxygen bomb calorimeter is determined by burning a certain amount of the reference amount of thermal benzoic acid under similar conditions. According to the temperature rise of the water in the calorimetric system before and after the sample is ignited, and the additional heat such as the ignition heat is corrected, the calorific value of the sample can be obtained. The high calorific value is obtained after the heat of the nitric acid is formed and the heat of the sulfuric acid is corrected from the calorific value of the cartridge.

2.2. Sample collection and pretreatment
The samples used in this study are mainly from A sewage treatment plant., For comparison, wastewater and sludge samples from wastewater treatment plants B, C and D were also collected during this period. Including sewage plant influent, effluent, primary sludge, excess sludge, mixed sludge and dewatered sludge. The average moisture content of the sludge was: 95.4%, 99.3%, 96.2% and 76.9%. The sample collection time was from January to February 2019, for a total of 35 samples. The samples are collected in plastic drums, sealed in a sealed box, and sent to the laboratory for pre-treatment within two hours. Manually shake the remaining sludge in the sealed box before performing sample analysis. Pour the sample into a 100 mL evaporating dish and dry it in a forced air oven at a temperature of (105 ± 3)°C until the mass is constant. Grind the dried sample into a fine powder with a mortar. The ground sample is then placed in a labeled glass test tube and placed in a desiccator for later use. The measurement of the index is preferably carried out on the day of grinding.

2.3. Test procedure
When measuring the calorific value of the combustion, weigh a certain amount of the grinding sample. Wrap in a quartz crucible with a mirror paper of known mass and unit weight calorific value. The mirror paper prevents the sample from splashing during the measurement process and has a high calorific value. For sludge and sewage samples that are not easily burned, they can play a role in combustion. Follow-up operations are performed according to the calorimeter requirements for automatic measurement. After the test, read the cartridge thermal value $Q_{b, ad}$ of the test sample. Calculate the high calorific value of the sample $Q_{gr, ad}$ with reference to the method for measuring the calorific value of coal.

$$Q_{gr, ad} = Q_{b, ad} - (94.1S_{b, ad} + \alpha Q_{b, ad})$$  \hspace{1cm} (1)

In the formula:
- $Q_{gr, ad}$ — Analyze the high calorific value of the sample (J/g)
- $Q_{b, ad}$ — Analyze the heat of the cartridge (J/g)
- $S_{b, ad}$ — Sample sulfur content (%)
- 94.1 — Correction value per 1% sulfur in coal (J);
- $\alpha$ — Nitric acid correction factor.

When $Q_b \leq 16.70MJ/kg \quad \alpha = 0.001$
When $16.70MJ/kg < Q_b \leq 25.1MJ/kg \quad \alpha = 0.0012$
When \( Q_b > 25.1MJ/kg \) \( \alpha = 0.0016 \)

Each sewage sludge sample was repeated 3 times. The same sample was analyzed for 3 times of repeated elements simultaneously.

3. Results and analysis

3.1. Results of calorific value determination of samples

The results of 3 parallel determination of each batch of samples are shown in Table 1. In this combustion heat test, the standard deviation of the drying base of sewage sludge samples from Sewage Treatment a is \( \leq 0.463\% \), and the relative standard deviation is \( \leq 0.147\% \). As a comparison of the combustion heat of similar samples from the three sewage treatment plants of B, C and D, the combustion calorific value of the lignite in China (high calorific value 12.510 kJ/g) is also listed and analyzed.

| Sample source | Water intake | Out of the water | primary sedimentary sludge | surplus sludge | Mixed sludge | dehydrated sludge |
|---------------|--------------|------------------|---------------------------|----------------|---------------|-------------------|
| A             | 4.015        | 0.177            | 7.110                     | 11.544         | 11.483        | 11.516            |
| A             | 4.485        | 0.273            | 13.440                    | 12.324         | 12.860        | 13.296            |
| A             | 4.088        | 0.273            | 12.622                    | 13.156         | 12.680        | 13.274            |
| A             | 3.862        | 0.225            | 11.024                    | 12.355         | 12.146        | 13.746            |
| A             | 4.164        | 0.296            | 13.544                    | 12.864         | 13.116        | 13.757            |
| B             | 4.282        | 0.355            | 13.184                    | 13.077         | 13.083        | 13.683            |
| C             | 4.322        | 0.323            | 0                         | 12.975         | 11.484        | 14.267            |
| D             | 5.864        | 0.351            | 0                         | 13.578         | 0             | 14.824            |

3.2. Sample element analysis and determination results

The average value of the results of three parallel elemental analysis of 5 batches of sewage sludge samples from A sewage treatment plant, expressed in mass percent, listed in Table 2.

| Sample source | Average mass percentage of elements (%) |
|---------------|----------------------------------------|
| Water intake  | C           | 13.84       | N           | 1.75        | S           | 3.46        | H           | 2.32        | O           | 22.86       |
| Out of the water primary sedimentary sludge | 5.60 | 2.25 | 4.45 | 1.14 | 18.65 |
| Surplus sludge | 26.67 | 3.05 | 1.45 | 4.74 | 21.97 |
| Mixed sludge | 26.46 | 3.67 | 1.30 | 4.85 | 25.75 |
| Dehydrated sludge | 27.88 | 3.40 | 1.24 | 4.86 | 20.11 |
| Mixed sludge | 28.15 | 3.98 | 1.37 | 4.96 | 22.75 |

From the analysis of sample elements, the mass content of combustible hydrogen in sewage sludge is not high, about 1% to 6%. In combustion, carbon and hydrogen provide the main heat of combustion. The higher the content of these two elements, the higher the calorific value of the mixed sludge. The content of elements such as C, H and O is slightly higher than that of mixed sludge. This is mainly because the mixed sludge is added with polyacrylamide during the dehydration process.
Increased the quality content of these elements. Therefore, the addition of an organic flocculant may result in an increase in the calorific value of combustion per unit mass of dewatered sludge.

The flammable sulfur in the sewage is mainly elemental sulfur and organic sulfur, and the content is relatively low, and the elemental sulfur content is only 0.65%. Its combustion product is $\text{SO}_x$. The combination with water to form dilute sulfuric acid produces heat of formation, which has a certain influence on the determination of the heat of combustion of the substance. When the oxygen content of a substance is higher, the more heat of carbon and hydrogen that is taken away by it, the lower the heat of combustion of the substance. Nitrogen element forms oxynitride $\text{NO}_x$ at high temperature, and combines with water to form dilute nitric acid, which generates heat of formation. Therefore, the presence of oxygen and nitrogen causes a decrease in the calorific value of the fuel.

4. Verification of calorific value analysis method

According to the results of elemental analysis, the high heat value of sewage and sludge is calculated using the classical Dulong formula:

$$Q_{gr} = 33.930C + 144.320 \times (H - 0.125O) + 9.300S + 1.494N \text{ (kJ / g)} \quad (2)$$

In the formula:
- $C$—Percentage by mass (%) of C in the dry basis per gram of sample (%);
- $H$—Percentage by mass (%) of H in the dry basis per gram of sample (%);
- $S$—Percentage by mass (%) of S in the dry basis per gram of sample (%);
- $O$—Percentage by mass (%) of O in the dry basis per gram of sample (%);
- $N$—Percentage by mass (%) of N in the dry basis per gram of sample (%).

The Dulong formula determines the organic carbon in the material as amorphous carbon, so 34.944kJ/g is used as its unit calorific value. The hydrogen in the substance is assumed to be in the form of water after combustion, so the heat of combustion is 146.330kJ/g. At the same time, the formula also assumes that all oxygen in the substance is combined with hydrogen. The content of combustible hydrogen in such a substance is relatively reduced, which is reflected in the formula. The measured calorific value is compared with the calorific value calculated by the Dulong formula and is listed in Table 3.

**Table 3. Comparison of determined calorific values and calculated ones of samples from A**

| Sample source                      | Dulong calculates high calorific value | Measured calorific value |
|------------------------------------|----------------------------------------|---------------------------|
| Water intake                       | 3.913                                  | 4.23                      |
| Out of the water                   | 0.26                                   | 0.26                      |
| primary sedimentary sludge         | 11.97                                  | 11.56                     |
| surplus sludge                     | 11.34                                  | 12.46                     |
| mixed sludge                       | 11.85                                  | 12.45                     |
| dehydrated sludge                  | 12.15                                  | 13.13                     |

It can be seen from the table that the measured values are in good agreement with the calculated values of the elemental analysis results, and the dehydration sludge calorific value is indeed slightly higher. It is indicated that the method for analyzing the calorific value of sewage sludge organic matter used in this experiment can be mutually verified with the elemental analysis method. There is no uniform and standard model for the determination of the calorific value of sewage sludge. This study aims to promote the standardization of urban sewage sludge calorimetry. The experimental research method is used as the basis for the measurement of chemical energy of sewage sludge organic matter. It is also possible to establish basic thermodynamic indicators for wastewater treatment systems. In the analysis of thermodynamic processes, the unit chemical energy index of organic matter is combined with the amount of sewage sludge entering and leaving the sewage treatment system. It can grasp the energy
utilization, composition and conversion of the system as a whole, thus providing an entry point for system energy saving or new technology development.

5. Conclusion
In this study, the C5000 calorimeter was used as a means to determine the calorific value of organic matter combustion in urban sewage sludge samples. The sample pretreatment was directly dried at 103-106°C. This study is the basic work to establish a thermodynamic analysis index system for wastewater treatment processes and a standard method for thermal analysis of sewage sludge.

The sludge drying base heat value of each process section is relatively high, basically above 12kJ/g, indicating that the municipal sewage sludge has a higher energy level.

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