Application research of waste red brick in water treatment

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Abstract. With the development of economy and the promotion of the three old reconstruction, the quantity of waste red brick is increasing. Improper disposal and application of waste red brick constitute a potential hazard of environmental pollution. The waste red brick has large specific surface area and porosity, which can absorb and filter sewage. In the experiment, the specific gravity and adsorption capacity of red brick sand and the adsorption effect of red brick sand on rhodamine B and methyl blue were investigated. The results show that the particle size of 10 mm is suitable for the red brick sand. The adsorption time was 4 h, the adsorption capacity of red brick sand reached 0.388 mL/g. The particle size of red brick sand was 30 mm, the dosage was 30.019 g/100 mL of water sample, and the decolorization rate of water sample reached 80.09%. It can be seen that red brick sand has good adsorption performance.

1. The introduction

According to the ‘Annual report on comprehensive utilization of resources in China’ (2014), at present, China produces about 1 billion tons of construction waste every year, while its utilization rate is less than 5% [1]. In November 2017, China added about 1.8 billion tons of construction waste every year [2]. Compared with the average recycling rate of over 90% in developed countries, the recycling rate of China's construction waste is less than 10% [3]. For every 10,000 m² old building demolished, 0.7-12,000 tons of construction waste will be generated. Waste clay bricks account for more than 50% of the total amount of construction waste [4], and broken bricks account for 50-70% of the construction waste in old city reconstruction [5]. Therefore, how to recycle waste civil engineering resources is particularly important.

Our country, as early as in March 2002 issued a text to require three to five years to cancel the red brick, but many old buildings with red brick as one of the main building materials, in the process of building demolition because of its strength is not high, often be destroyed, and finally be discarded buried, resulting in a waste of resources. The old red brick has the feature of multi-porosity, which can be used as a new adsorption material. There is only a "reuse" distance between "construction waste" and "resources", and the construction waste will be turned into treasure, so as to achieve win-win results in ecological, social and economic benefits [6].

Quartz sand is commonly used as filter material in sewage concentration treatment [7]. However, red brick particles are porous (its porosity is about 37%), with high adsorption efficiency and strong permeability, and their properties are stable after sintering. Red brick particles are used to replace quartz sand in sewage treatment, and sewage is treated by adsorption and filtration. Quartz sand is often used as filter material in the filtration process of tap water, tower water and well water, which
can remove or reduce impurities such as water turbidity, chroma, organic matter and microorganism to a certain extent. The old red brick has strong adsorption and decolorization, which can also replace quartz sand. In this way, river sand and sea sand can be gathered [8]. It can not only protect the riverbed, reduce the excavation of river sand and sea sand, but also achieve the effect of energy conservation, environmental protection and recycling of resources.

2. Experiment part

2.1. Principle analysis
Red brick is also called clay brick. The main raw material is clay (clay), which is crushed, mixed, pinched and pressed into shape. After drying, it is sintered with oxide flame at 900 ℃, so it is red. Even after several decades, its physical properties are still very stable, and porous, because of the physical and chemical properties of clay brick itself, it has a large water absorption rate, crushing index, with potential activity and other characteristics. Its properties are similar to those of common ceramsite and quartz sand, which can be used as good adsorption materials. Therefore, this project will take ceramsite and quartz sand as the comparison objects. In this project, the adsorption degree of ground red brick particles, ceramsite and quartz sand particles of different thickness was discussed. In order to facilitate observation, methylene blue solvent was used to simulate pollutants. After sorting and drying 7 kinds of granulated materials with different materials and particle sizes, a dc mixer was used to continuously stir at the same rotation speed and sample at the same interval to obtain the relative ratio of adsorption degree, so as to judge the adsorption effect.

2.2. Experimental materials
Waste red brick, rhodamine B, methyl blue.

2.3. Experimental instruments
G16G bench high speed centrifuge (Changzhou yineng experimental instrument factory), small planetary ball mill (Nanjing daran technology Co., LTD.), ME204TE analytical balance, 722N visible spectrophotometer, a series of Taylor standard screen.

2.4. Scheme design
(1) 30 (series A), 25 (series B), 20 (series C), 15 (series D), 10 (series E), 5 (series F) mm were prepared by hammer and ball mill.
(2) Determination of sand specific weight and adsorption capacity of red brick: waste red brick of series B, C, D, E and F with different particle sizes were weighed into 30 g, put into 100 ml measuring cylinder, and add 40 mL distilled water. After 5 minutes, if the water sample increased to 49 mL, the proportion of waste red brick was 30/ (49-40) =3.33.
(3) Comparison of adsorption effect of red brick sand for 30 min: waste red brick of series B, C, D, E and F were divided into 30 g, put into 100 mL measuring cylinder, add 40 mL distilled water, after 30 minutes, if the water sample rose to 49 mL, the adsorption capacity of waste red brick was (49-40)/30=0.3 mL/g. Note: step 2 and step 3 use the same water sample.
(4) Comparison of absorbance and chroma of water samples after 30 minutes of adsorption: waste red bricks of C, D, E and F series are divided into 30 g, put into 100 mL measuring cylinder, add 40 mL 1 g/L methyl blue solution, after 30 minutes, the water samples are centrifuged to determine the absorbance and chroma of each water sample.
(5) The influence of the amount and time of red brick sand on the adsorption capacity of rhodamine B water sample: 10 mm diameter of red brick sand was selected, and the amount of red brick sand was about 10, 20, 30, 40, 50 g, respectively. The adsorption time was 1,2,5,7 h, respectively, to detect the adsorption capacity of red brick sand.
(6) The influence of the amount and time of red brick sand on the adsorption effect of methyl blue solution: red brick sand with 10 mm diameter, 102 mg/L methyl blue solution, 100 mL was selected.
Treatment of red brick sand: first rinse with tap water, then rinse with distilled water, and finally dry at 105 ℃ for 2 hours. Blow the red brick sand surface with ear washing ball and measure the absorbance with 5 mL solution each time. The absorbance of the original methyl blue solution was 1.080, and the wavelength of visible light spectrophotometer was 664 nm. The mass of red brick sand was set to be 10, 20, 30, 40, 50 g, and the adsorption time was 5, 10, 15, 20, 25, 30, 35, 40, 120, 240 min, respectively, to detect the absorbance of water samples, and then calculate the decolorization rate of water samples.

3. Results and talk

3.1. Pellet preparation
The main raw material of waste red brick is clay with strong adsorption capacity and good permeability. Waste grain raw material is the mineral and rock used for firing light building material ceramsite. It has high porosity and good isolation. Soak the waste red brick in water for 2 hours, remove the surface pollutants, dry, hammer into particles of different particle size, through the Tyler standard sieve, get the waste red brick particles of different particle size.

3.2. Determination of specific weight and adsorption capacity of red brick sand
According to the above experimental scheme, the measured data are shown in Table 1.

| Particle size of red brick sand (25 mm, 20 mm, 15 mm, 10 mm, 5 mm, 12 hole, 20 hole) | Amount of red brick sand (g) | Water level scale after adding 50 mL distilled water (mL) | Water level scale after 10 hours (mL) | Red brick is heavier than sand | Adsorption capacity of red brick sand (mL/g) |
|---------------------------------|-----------------------------|---------------------------------|---------------------------------|-------------------------------|---------------------------------|
| 25 mm                           | 30.471                      | 65.1                            | 64.0                            | 0.04                          |
| 20 mm                           | 30.775                      | 65.0                            | 64.0                            | 0.03                          |
| 15 mm                           | 30.380                      | 64.0                            | 63.0                            | 0.03                          |
| 10 mm                           | 30.442                      | 64.0                            | 63.0                            | 0.04                          |
| 5 mm                            | 30.247                      | 65.0                            | 63.0                            | 0.07                          |
| 12 hole                         | 30.069                      | 64.5                            | 63.0                            | 0.06                          |
| 20 hole                         | 30.007                      | 63.2                            |                                  | 0.03                          |

3.3. Comparison of adsorption effect of red brick sand for 30 min
Weigh 30 g of red brick sand with different particle sizes, put it into a 250 mL beaker, add 50 mL rhodamine B solution with concentration of 500 mg/L, after 9 h, centrifuge the water sample and then dilute it 100 times to determine the absorbance. The absorbance of raw water is 47.80, as shown in Table 2 and Figure 1.

| Particle size of red brick sand (25 mm, 20 mm, 15 mm, 10 mm, 5 mm, 12 hole, 20 hole, Blank) | Amount of red brick sand (g) | Absorbance | Decolorization rate |
|---------------------------------------------------------------------------------------------|-----------------------------|------------|---------------------|
| 25 mm                                        | 29.173                      | 0.416      | 12.97%              |
| 20 mm                                        | 30.064                      | 0.431      | 9.83%               |
| 15 mm                                        | 29.631                      | 0.356      | 25.52%              |
| 10 mm                                        | 30.226                      | 0.342      | 28.45%              |
| 5 mm                                         | 30.010                      | 0.462      | 3.35%               |
| 12 hole                                      | 30.010                      | 0.423      | 11.51%              |
| 20 hole                                      | 30.009                      | 0.416      | 12.97%              |
| Blank                                        | 0                          | 0.478      | -                   |
According to the analysis in Table 2 and Figure 1, the particle size of red brick sand is selected to be 10 mm.

3.4. Influence of the amount and time of 10 mm particle size of red brick sand on the adsorption effect of rhodamine B water sample

Water sample: 250 mg/L rhodamine B solution 100 mL, see Table 3 and Figure 2.

Table 3. Influence of amount and time of red brick sand on adsorption capacity of rhodamine B water sample

| Amount of red brick sand (g) | 20.02 | 30.082 | 40.058 | 49.927 | 0 |
|-----------------------------|-------|--------|--------|--------|---|
| Adsorption capacity of 1 h (mL/g) | 0.383 | 0.298 | 0.347 | 0.311 | 0.462 |
| Adsorption capacity of 2 h (mL/g) | 0.407 | 0.329 | 0.337 | 0.269 | 0.329 |
| Adsorption capacity of 5 h (mL/g) | 0.408 | 0.379 | 0.379 | 0.403 | 0.426 |
| Adsorption capacity of 7 h (mL/g) | 0.422 | 0.388 | 0.400 | 0.408 | 0.445 |

Note: The above is the chroma after dilution of 50 times, the absorbance of raw water is 47.80. Taking the dosage of 30.082 g as an example, Figure 2 is shown below.

As can be seen from Table 3 and Figure 2, the adsorption capacity of red brick sand on rhodamine B water sample increases with the extension of reaction time.
3.5. Influence of the amount and time of 10 mm particle size of red brick sand on the adsorption effect of methyl blue solution

Water sample: 102 mg/L methyl blue solution 100 mL, the experimental results are shown in Table 4, Figure 3-6.

**Table 4. Influence of amount and time of red brick sand on adsorption effect of methyl blue solution**

| Quality of red brick sand | 10.035 g | 20.019 g | 30.019 g | 40.092 g | 50.045 g |
|--------------------------|----------|----------|----------|----------|----------|
| Time (min)               | Absorbance | Decolorizat ion rate (%) | Absorbance | Decolorizat ion rate (%) | Absorbance | Decolorizat ion rate (%) | Absorbance | Decolorizat ion rate (%) | Absorbance | Decolorizat ion rate (%) |
| 5                        | 0.950     | 12.04    | 0.882     | 18.33     | 0.872     | 19.26     | 0.842     | 22.04     | 0.875     | 18.98     |
| 10                       | 0.920     | 14.81    | 0.874     | 19.07     | 0.849     | 21.39     | 0.860     | 20.37     | 0.806     | 25.37     |
| 15                       | 0.909     | 15.83    | 0.853     | 21.02     | 0.787     | 27.13     | 0.765     | 29.17     | 0.731     | 32.31     |
| 20                       | 0.880     | 18.52    | 0.796     | 26.30     | 0.737     | 31.76     | 0.720     | 33.33     | 0.630     | 41.67     |
| 25                       | 0.843     | 21.94    | 0.744     | 31.11     | 0.689     | 36.20     | 0.642     | 40.56     | 0.562     | 47.96     |
| 30                       | 0.820     | 24.07    | 0.704     | 34.81     | 0.627     | 41.94     | 0.591     | 45.28     | 0.518     | 52.04     |
| 35                       | 0.798     | 26.11    | 0.679     | 37.13     | 0.598     | 44.63     | 0.541     | 49.91     | 0.460     | 57.41     |
| 40                       | 0.784     | 27.41    | 0.625     | 42.13     | 0.556     | 48.52     | 0.488     | 54.81     | 0.444     | 58.89     |
| 120                      | 0.561     | 48.06    | 0.400     | 62.96     | 0.307     | 71.57     | 0.254     | 76.48     | 0.193     | 82.13     |
| 240                      | 0.392     | 63.70    | 0.278     | 74.26     | 0.215     | 80.09     | 0.177     | 83.61     | 0.154     | 85.74     |

Reaction during 240 min, red brick sand dosage and the relationship between the absorbance of the methylene blue solution, and the decolorization rate, the relationship between respectively as shown in Figure 3, Figure 4. Visible, with the increase of dosage of red brick sand, waste-water decolorizing rate increases, but waste red-brick dosage is 30.019 g, waste-water decolorizing rate increase is not obvious, so 30.019 g is the best dosage of the red brick of sand.

![Figure 3. The relationship between the amount of waste red brick and its absorbance](image)

![Figure 4. Relationship between amount of waste red brick and decolorization rate](image)

In the amount of waste red brick of 30.019 g, the adsorption time is related to the absorbance and decolorization rate of methyl blue solution, as shown in Figure 5 and Figure 6.
4. Conclusion

China produces a huge amount of construction waste every year, and the waste red brick, if not properly disposed of, poses a potential environmental threat. The waste red brick has large specific surface area and porosity, which can absorb and filter sewage. The particle size, specific gravity and adsorption capacity of red brick sand were investigated, indicating that the appropriate values were 10 mm, 17.65 and 0.388 mL/g, respectively. With the increase of the amount of red brick sand and the extension of the adsorption time, the adsorption effect is enhanced. Under the condition of adsorption time of 4 h and dosage of 30.019 g/100mL water sample, the chroma of the water sample was reduced to 0.215, and the decolorization rate reached 80.09%. It can be seen that the red brick sand has good adsorption performance.

Acknowledgments

This work was supported by 2019 Student Innovation and Entrepreneurship Training Program of Academic Affairs Office, from Guangzhou College of Technology and Business.

References

[1] Annual report on comprehensive utilization of resources in China [R]. National development and reform commission, 2014.
[2] Lan Cong, Lu Jialin, Chen Jing, et al. Status Quo and Development Analysis of Resource Utilization of Construction Waste in China [J]. Eady - Mixed Concrete, 2017, (9): 23-25.
[3] Zheng Hua, Lou Yuefeng. Exploration on the utilization of building waste clay bricks [J]. Henan building materials, 2019 (4) : 167-168.
[4] Liu Rongtao, Zhu Jianhui. Comprehensive utilization of building waste clay brick [J]. Chinese journal of ceramics, 2016, 35 (10): 3191-3195.
[5] Li Shoude. Feasibility of producing sintered building materials from construction waste [J]. 2005, 12 (1): 36-38.
[6] Shen Beibei. Application of random sampling in red brick inspection and testing [J]. Private science and technology, 2013, 12 (1): 40.
[7] Sun T C, Lou J S. Water pollution control engineering. Beijing: machinery industry press, 2010. (in Chinese)
[8] Jiang Zhanpeng. Environmental engineering. Beijing: higher education press, 2002.