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Characteristics of typical heavy metals removal abilities in Fuzhou domestic wastewater treatment process

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ABSTRACT

In this paper, the removal characteristics of five heavy metals (Mn, Fe, Zn, Cr, As) in two urban wastewater treatment plants called A and B in Fuzhou were studied. The results showed: (1) The influents of these two wastewater treatment plants weren't seriously polluted by heavy metal heavily except for Mn and Fe, this may result from the environmental background of Fuzhou; (2) A takes A/O process as the biological unit, the removal efficiencies for these heavy metals of the whole process ranged from 7.5% for Zn to 93.1% for Fe. (3) B utilizes CASS process for secondary treatment, it yielded lower removal efficiencies than A/O process on the whole, ranging from 28.5% for Mn to 88.2% for Fe except Zn; (4) Both A and B were excellent in removing Fe while had little removal efficiency for Zn, this may result from the re-dissolution of particulate Zn; (5) the removal capacities for heavy metals of these two wastewater treatment plants were calculated respectively, ranging from 0.03 kg •d-1 to 18.10 kg •d-1.

KEYWORDS

Activated sludge;
Distribution, removal characteristics;
Heavy metal;
Wastewater treatment plant.

INTRODUCTION

A large number of experimental research and engineering practice shows that the heavy metal in urban wastewater were effectively removed during the wastewater treatment process[1,2]. There were wide range sources of heavy metals in urban wastewater, which were seriously eco-toxic. The species distribution of heavy metals in biological wastewater treatment process, removal and migration trends, influencing factors and other issues need further study. To investigate the distribution of metal ions in various processing units is the key factor to distinguish the metal migration and transformation mechanism in wastewater treatment plant[3,4]. It has been observed that increasing pH favors the adsorption of metal ions because of less competition between H^+ and metal ions for adsorption sites[5].

Heavy metals in the sewage treatment process, refers to the toxic metals. Both metals significant toxicity, but also in the human body are displayed when excessive accumulation of toxic metals. Sources of heavy metals in municipal wastewater can be specific to roof runoff, tires, food, etc., can also be a car wash, industrial activities, etc.[6,7]. People's daily life, industrial activities and storm water runoff contains large concentrations of heavy metals in considerable[8], which is the main source of heavy metals in sewage[9]. Since heavy metals easily soluble in water environments and organisms that can be absorbed, once they enter the food chain, the accumulation in the body[10]. When their concentration in the body if accumulated to a certain threshold, it will show toxicity to human health threat.

Activated sludge process in the effective removal of organic matter in sewage, but also through sedimentation, adsorption of heavy metals in sewage removal[11]. Studying the migration and distribution abilities of heavy metals in sewage treatment plants if very important in each WWTP[12]. In this study, two typical WWTP in Fuzhou were studied to investigate the Fe, Mn, Zn, As, Cr in the distribution of each processing unit to analyze the characteristics of each element to remove the sewage treatment plant to remove the elements of capability.

MATERIALS AND METHODS

Instruments and reagents

Equipment: electronic balance (FA2004N, Shanghai Precision Instrument Co., Ltd.); Centrifuge (TDL-5, Shanghai Anting Scientific Instrument Factory); inductively coupled plasma mass spectrometer (7700X, Agilent Technologies, Inc.).

Reagents: excellent pure nitric acid; analytical grade nitric acid; ultrapure water; Fe, Mn, Zn, As and Cr standard solution.

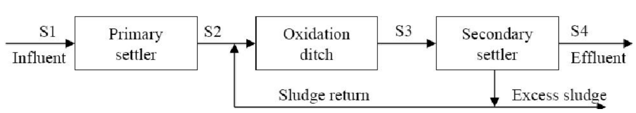

Figure 1 : Schematic flow diagram and sampling point of the WWTP

Sample collection

A wastewater treatment plant processing capacity 75,000 tons, the influent to wastewater main, single-stage denitrification A/O (anoxic/aerobic) processes to fine grid, aerated grit chamber, A pool, O pool, secondary sedimentation tank, disinfection tank effluent and return sludge as water samples. B wastewater treatment plant daily processing capacity of 50,000 tons, mainly university town and some residential areas receiving effluent, using CASS process, select the gate well, cyclone grit chamber end of the pool disinfection end of sampling points.

Sample preparation

Evenly mixed sample was placed in 50mL centrifuge tubes, electronic weighing scales such as the sample weight; the sample into the centrifuge, in 5000 rpm speed centrifuged 30min[13]. Water through 0.45μm filter membrane to separate the sample dissolved heavy metals and particulate heavy metals, and the filtrate was sung in 50mL colorimetric tube, the volume to 25mL, in order to harmonize acidification. With the excellent level of pure nitric acid adjusted to pH between 1 and 2 in order to prevent metal precipitation. After acidification of the sample was stored at 4 °Cconditions, to prepare for inspection.

Sample detection method

Instrumentation for the inductively coupled plasma mass spectrometry (ICP-MS), using the internal standard method for each standard solution and the sample contents of heavy metals were detected, the heavy metals concentration of standard solution selected according to their content in water samples have the distinction.

RESULTS AND DISCUSSION

ICP-MS detection result of the standard solution and the correlation coefficient

As can be seen from TABLE 1, As, Mn, Fe and Cr, the correlation coefficient was 0.9999 or more, and Zn linear rival, is 0.99980. Description ICP-MS in the concentration range of excellent linearity, high reliability test results.

The distribution of heavy metals in the processing unit and variation

A line drawing of two wastewater treatment plants of each processing unit water content of heavy metals in order to observe each processing unit in the and the wastewater treatment process variation, shown in Figure 2.

Figure 2 shows two wastewater treatment plant influent concentration of heavy metals in the same order of magnitude, e.g. Mn>Fe>As>Cr. Mn and Fe content is high and Fuzhou region and sewers environmental

TABLE 1 : ICP-MS as measured by the concentration of the standard solution and the correlation coefficient μg • L-1

metal	0	2	5	20	50	200	500	r
Mn	0.51	2.32	4.77	19.50	50.22	200.96	499.47	0.99998
Fe	0.10	2.06	4.99	19.85	50.06	202.06	499.16	0.99998
Zn	0.16	1.99	4.95	19.81	50.08	192.56	502.87	0.99980
As	0.00	2.01	4.98	20.00	50.44	—	—	0.99999
Cr	<0.0	2.01	5.01	20.00	50.94	—	—	0.99997

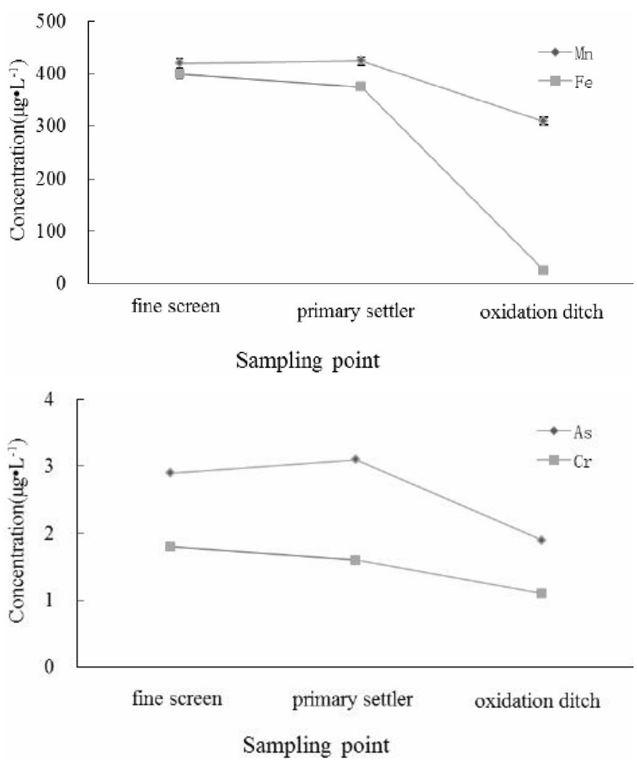

Figure 2 : Migration of heavy metals in WWTP

background material relating, in addition, some of the water units and residents direct use of groundwater or surface water, may also lead to the Fe, Mn content increases[8]. It should be noted, in this thesis is the dissolved concentration. Since the two wastewater treatment plants are mainly wastewater, As and Cr, influent concentration is very low, in the 3 μg • L-1 or less. It can be seen in the wastewater treatment process, the content of heavy metals in general decreasing trend, two wastewater treatment plant effluent is less than most of the heavy metals concentrations in water values.

Heavy metals removal and removal mechanisms discussed

Through comparing the cell size of heavy metals, heavy metals can be drawn in each of the processing unit to remove the case, by the equation (1), (2) to calculate the removal of the processing unit. Similarly, by comparing the heavy metals out of the water, using the formula (3) can be concluded that the entire process for the removal of heavy metals. Two wastewater plants each processing unit and the entire process on the removal of heavy metals as shown in TABLE 2. From TABLE 2 and Figure 3 shows that A plant aerated grit chamber for Mn, Fe, As and Cr did not remove the effect of these four elements, the grit chamber effluent water content and fine grid within ± 5% difference in, only the Zn was removed, Zn particles by adsorption and the solid was removed. A pool of Mn, Zn, As and Cr content is increased, the return sludge may be part of the heavy metals desorption results. A pool because there are a lot of dissolved organic matter and the formation of complexes with heavy metals, affecting the activated sludge adsorption of heavy metals[14]. O pool gradually dissolved organic matter is degraded, with complexation of heavy metals also will be active sludge adsorption, O pool all elements concentrations are decreased, the removal rate ranging from 8.1~69.4%. O pool of various heavy metals removal mechanism is adsorbed on the surface of activated sludge microorganisms and intracellular accumulation. In addition to Zn, secondary sedimentation tank for removal of the remaining elements of between 31.8 ~ 80.3%. Secondary settling tank particulate matter mainly through adsorption, co-precipitation of heavy metals and other elements of the physical and chemical effects on the removal. This shows that the dissolved metals in biological cells and two primary settling tank be removed, which is consistent with the findings Sung[15]. In addition to disinfection tank outside of Mn has no effect on the remaining elements are 13.0 to 35.2% removal rate, there is no research on the disinfection tank removal investigation. UV light irradiation may affect the adsorption of heavy metal particles in water or affect the solubility of heavy metals in water, heavy metals in the ultraviolet disinfection tank removal reasons that will be further studied in future experiments. The entire process on the removal of heavy metals between 49.3 to 93.1%, with the smallest removal efficiency of Mn, and highest removal efficiency of Fe.

TABLE 2 : A wastewater treatment plant each processing unit and the removal of the entire process

metal	Sand chamber	A ditch	O ditch	Second sedimentation	Disinfection pool	total removal efficiency
Mn(%)	4.5	-18.4	30.0	31.8	-9.1	49.3
Fe(%)	0.0	14.2	69.4	80.3	18.6	93.1
As(%)	-2.5	-30.8	38.1	37.4	13.0	62.7
Cr(%)	-2.8	-62.3	8.1	68.9	35.2	65.9

TABLE 3 shows that the Mn, As and Cr were not obviously removed by fine screen chamber in B factory for the effect of these three elements, the water content in the grit chamber contents gate wells within a difference of ± 8%, for Fe some removal, Fe may be removed with the solid particles, Zn instead of the content of this element increases. In the CASS pool, all elements concentrations are decreased, with the removal of heavy metals ranging from 13.3 ~ 85.6%. CASS pool of various heavy metals removal mechanisms of microbial adsorption (adsorption and showed intracellular accumulation) and particulate matter through adsorption, precipitation and other physical and chemical effects. The entire process on the remaining elements Mn removal from 28.5% to 88.2% of Fe.

TABLE 3 : B WWTP each processing unit and the removal of the entire process

metal	fine screen-sand chamber	Biological process	total removal efficiency
Mn(%)	1.4	27.5	28.5
Fe(%)	18.2	85.6	88.2
As(%)	-7.7	38.4	33.6
Cr(%)	4.2	26.4	29.5

Comparing the two wastewater treatment plants for removing heavy metals, A wastewater treatment plant had the higher removal rate of all the elements than the B wastewater treatment plant, which indicated that A/O process had more heavy metal removal rate than CASS process, which may be associated with A/O process aeration time. Two wastewater treatment plant removal rate of Fe can reach about 90%, but their ef-

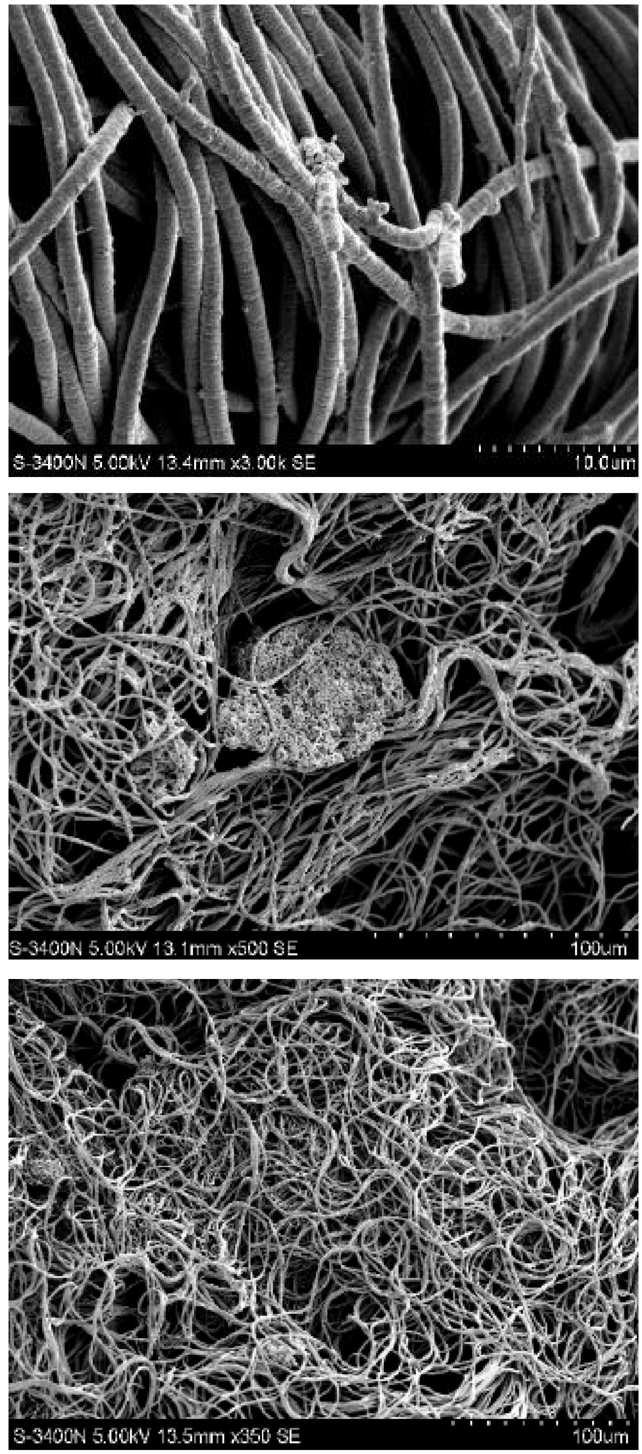

Figure 3 : SEM image of the activated sludge

fect on the removal of Zn are poor, even increase its content. This may be due to the water in a high proportion of particulate Zn and particulate heavy metals harder than removing dissolved metals[10], and the proportion of the water solubility of Zn tendency to increase[11]. Therefore, how to improve the wastewater treatment plant for removal of dissolved Zn is the next focus of the study, not only to the removal mechanism of Zn to do further research, but also put forward the economic and technical feasibility of implementation used in the actual project.

Effect of adsorbent characteristics and adsorption parameters

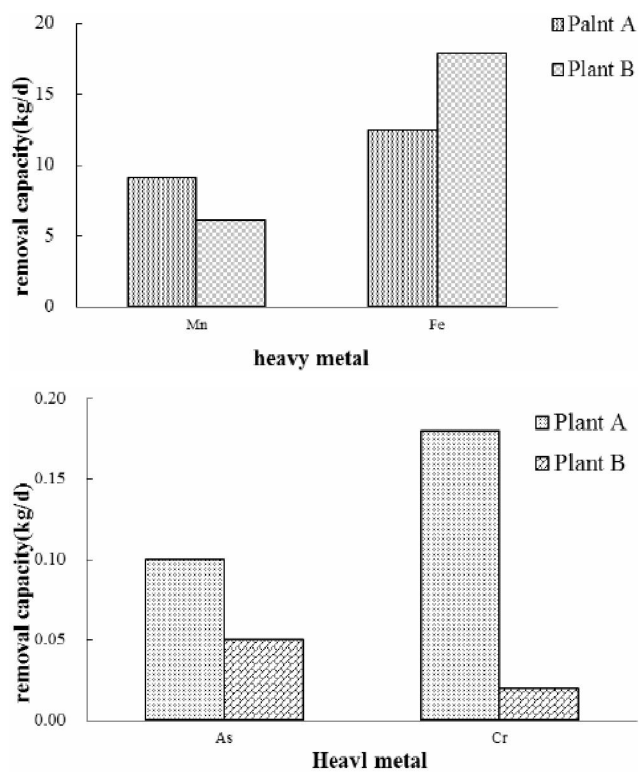

Figure 4 : Heavy metal removal capacity in two WWTP

Forecast heavy metal removal capacity of wastewater treatment plant

The heavy metals removal capacities in the two wastewater treatment plants were investigated.

The two wastewater treatment plants had the largest removal ability of Fe, with daily removal rate of more than 10kg. Fe concentration in B wastewater treatment plant was 130% higher than A wastewater treatment plant, although the removal rate is less than A, the daily removal capacity is still about 50% higher than A. Mn had the second highest removal rate, and the two wastewater treatment plants removed more than 5kg Mn every day. While the As and Cr removal rate were less than 0.4kg. The different removing rates of these elements were from the different elements concentration in raw water and wastewater treatment plants for removal of the elements.

CONCLUSIONS

(1) The Fe and Mn concentration in influent of the two wastewater treatment plants were higher, which may be related to the environmental background of Fuzhou. Since the two wastewater treatment plants were mainly domestic wastewater, Cr and As concentrations are less than 3 μg • L-1. Its influent heavy metal pollution situation is not serious, and heavy metals in the effluent of the indicators are better than emissions standards.

(2) The Mn, Fe, Cr and As were mainly removed in O pool with secondary sedimentation tank, and Cr mainly in the secondary settling tank was removed, Zn mainly in the grit chamber in A wastewater treatment plant. The total removal rates of Mn, Fe, Zn, As, Cr were 49.3%, 93.1%, 7.5%, 62.7%, 65.9% respectively in the entire process.

(3) The heavy metals are removed primarily in the biological unit in B wastewater treatment plant. The total removal rates of Mn, Fe, As, Cr were 28.5%, 88.2%, 33.6%, 29.5% respectively.

(4) The daily removal capacity of Mn, Fe, Zn, As, Cr in A wastewater treatment plant presumably were 8.75 kg, 11.98 kg, 0.37 kg, 0.10 kg, 0.17 kg, while in B wastewater treatment plant on Mn, Fe, As, Cr were 6.29 kg, 18.10 kg, 0.05 kg, 0.03 kg.

(5) How to improve the removal of dissolved Zn and disinfection tank for removing heavy metals will be continue studied in future experiments.

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