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FEATURES OF WASTE WATER QUALITY IN ZONGGUAN WATER PLANT

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ABSTRACT

This paper takes waste water from Zongguan waterworks as a research object. The waste water was monitored consecutively and found that: the SS of waste water was more than 90 times of which in original water, COD was more than 30 times, and Fe was 58 times. The SS and turbidness showed no linear relation except when they were lower. The SS and Fe accord with linearity relation was better. The difference between waste water that from overhead crane at the beginning and in the end was wide. Although the flux of backwash wastes was small but the impact of it over the quality of water was very high.

Keywords: waterworks, waste water, quality analysis.

1. INTRODUCTION

Zongguan water plant which belongs to Wuhan water company locates on the Zongguan area in the middle part of Qiaokou district. There is a distance of 6.4km between it and the convergence of Yangzte river and Hanjiang. The water plant occupies 184000 square meters and its water source is Hanjiang. It was started in 1906 and founded in 1909. Its initial scale is 270000 square meter per day. The water plant developed very slowly in 43 years before the birth of People's Republic of China. In the eve of founding of PRC, the daily comprehensive productive ability was only 930000 square meter. After the founding of PRC, it insists on both of epitaxial expansive reproduction and connotative expansive reproduction. It was constantly rebuilt and improved. At present, the theoretically productive quantity is 630000 to 640000 ton. It has to meet the needs of supplying industrial water and municipal water from Qiaokou to Huangpu Lu, including 4 administrative areas in Hankou and drinking water to about 1500000 people. The daily water supply is 36% of that in Wuhan water company. The water plant plays an important role in developing economy in Hankou and uplifting the people's life. It is the biggest water plant in Wuhan and ranks 4th in same industry in the country [2,3].

1.1 Getting water of water plant

Zongguan water plant adopts the floating boat to get water directly from Hanjiang. There are 5 floating boats and each can get 30wt water daily. There are some problems in getting water nowadays:

(a) The pollution is severe in the water of Hanjiang and the water quality gets bad. Especially the potential leakage of chemical substance in Dongxihu Chemical Plant in the upstream of Hanjiang greatly threatens the safety of water source.
(b) The construction of the upstream sand quay and Jianghan Second Bridge influence the changing of current direction in intakes, making it shallow in intakes.
(c) The dams which built for south to north water diversion causes the changing of water quality in Hanjiang. Especially in low water season, the influence is more obvious.
(d) The water level is relatively low in low water season and the rocker arm of floating boat is short, the swing angle is small, which affect getting water. Even we can't get water in lower water season.
(e) The floating boat supplies water to water plant by 2 DN2200 Pipes. The pipes have to cross motor vehicle lane, which poses danger to safety.

1.2 The productive craft in water plant

Zongguan water plant introduces internationally and nationally advanced instruments to produce, transfer, purify and automatically monitor water. It adopts various modern productive testing means such as the reliable online water quality apparatus. The purifying crafts coordinate well. All these make all the indicators of water quality meet or surpass the turbidity required in Water Quality Sanitation Regulation for Drinking Water [4].

Zongguan water plant adopts conventional processing crafts: coagulating-sediment-filtering-chlorinated. It uses polymeric aluminum potassium sulfate (PAFS) as coagulant, which is casted by pressure pipe in front of the reactor flocculation basin. The quantity of coagulant depends on the turbidity in raw water. According to the changing scope of turbidity in raw water is between 10 NTU and 1980 NTU. At present, the turbidity in raw water is 30 NTU; the dosage is 13 to 15 kilogram standard alum per thousand ton of water.

1.2.1 Flocculation

There are 6 gridding flocculation basins (the first one is suspended, the sixth is spare) in reactors in water plant. There are 3 groups in the 2nd, 3rd, 4th and 5th flocculation basins, and 5 groups in the 7th. There are 3 reaction tanks in one group and each processes 3wt/d.

There is a 2-meter broad settling zone between flocculation basin and sedimentation basin. At the bottom of the sedimentation area there is a 1.5m retaining wall

that greatly strengthen the sedimentation of sand and mud, which is proved in practical operation. There are two ways to drain mud in flocculation basin:

(a) Draining mud by small vehicle: there is a small vehicle in each group in flocculation basin. It is used to drain mud and sand between flocculation basin and sedimentation basin. The gauge of vehicle: the weight is 2T, the span is 2.375m, the flow rate is 144m/h, and the speed of travel is 1m/min. The cycle vehicle of vehicle is different as the turbidity differs. When turbidity is around 30NTU, the cycle of vehicle is 12 hours. Two vehicles are used to drain mud each time. At each time it lasts 34 minutes. The time is once at 12 a.m. and once at 12 p.m.
(b) Draining mud by reaction perforated pipe: there are 4 perforated pipes in every reaction tank. Each time it last 20 seconds for each perforated pipe to drain mud, and the flow rate is 1.9m3/min. The cycle of perforated pipe is 12 hours. The time is once at 12 a.m. and once at 12 p.m.

1.2.2 Sedimentation basin

There are 6 pipe chute sedimentation basins (the first one is suspended, the sixth is spare) in water plant. There are 3 groups in the 2^{nd}、3^{rd}、4^{th}、and 5^{th} sedimentation basin and 5 groups in the seventh. The big vehicle is used to drain mud. There is a big vehicle in each group. The gauge of a big vehicle: the weight is 14T, the span is 18.85m, the flow rate is 576m/h, and the speed of travel is 1m/min. The cycle of a big vehicle to drain mud is 24 hours. 2 vehicles begin to work at 12 p.m. Each time it lasts 34 minutes for each vehicle to drain mud.

1.2.3 Filter chamber

There are 4 v typed filter chambers in this water plant---the 2^{nd}, 4th, 5th, and 7^{th}; 2 normal filter chambers---the 3^{rd}, 6^{th}, which are suspended now. There are 10 gridding in the 2^{nd},4^{th} ,5^{th} and 16 gridding in the 7^{th} .The area of each gridding of filter chamber is 11.8m × 8m = 94.4m^2.The gas and water flushing is used in filter chamber. The gas flushing lasts 3 hours and its intensity is 15L/s.m^2; the gas and water flushing lasts 4 minutes and gas intensity is 7.5L/s.m^2 and water intensity is 2.72L/s.m; the water flushing lasts 5 minutes and its intensity is 5.4L/s.m; the surface flushing intensity is 1.4L/s.m. The cycle of flushing in filter chamber is 48 hours. Each time it begins at 12 p.m. and 2 chambers are used.

1.3 Discharging of factory effluent

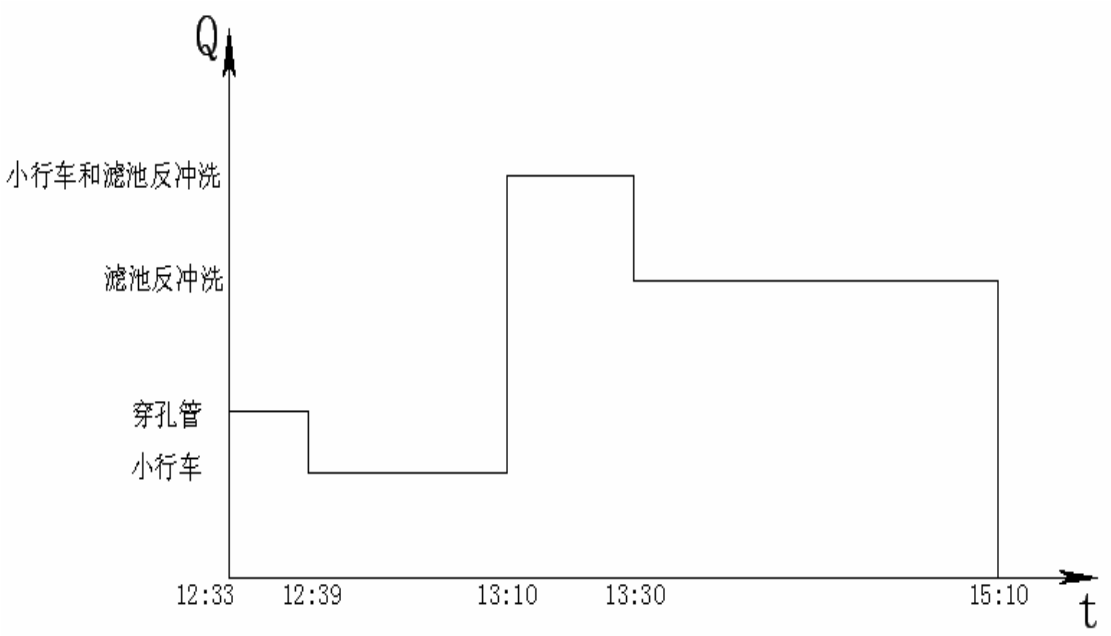
The mud water from perforated pipes, small vehicles, big vehicles and counter flushing water from filter chambers converge in drainage and then drain away. When the water level of Hanjiang is below 25.8m, the factory effluent can be directly drained into Hanjiang by drainages. The waste water sample used in our experiment is got from the drainages into Hanjiang, namely drains. When the water level is above 25.8m, the waste water can not be directly drained into Hanjiang. Instead, it is drained into dredge pump stations and then into Hanjiang.

2. MATERIALS AND METHODS

2.1 Waste water sampling

We analyze the water quality by constantly monitoring and sampling the factory effluent in drains to have a good knowledge of the draining rules of waste water and its features of water quality. The detailed sampling arrangement was:

At 9:15 in the morning, we sample one from raw water and one from polluted water in factory.
At 12:33, the draining of water in drains begins. At noon, only the perforated pipes, small vehicles in the 2^{nd} and 3^{rd} flocculation basins begins to drain mud, and the counter flushing in the 2^{nd} filter chamber begins. The perforated pipes drain mud from 12:33 to 12:39. There are totally 72 perforated pipes in the 2^{nd} and 3^{rd} reaction tanks. Each time 4 perforated pipes are used to work and it lasts 20 seconds. The total time is (72/4) × (20/60) = 6 min. Small vehicles begin to work at 12:39. Each time 2 vehicles is used to work. It takes 17 minutes for each vehicle to work. There are totally 6 small vehicles in the 2^{nd} and 3^{rd} reaction tanks. The totally time is 51 minutes, span from 12:39 to 13:30. At 13:10, the 2^{nd} filter chamber begins counter flushing. The gas flushing lasts 3 minutes (13:10-13:13); the gas and water flushing lasts 4 minutes (13:13-13:17); the water flushing lasts 5 minutes (13:17-13:22). 10 gridding of filter chamber need counter flushing, so the time span of counter flushing in filter chamber is from 13:10 to 15:10. The detailed time to drain mud refers to Figure-1.



Figur-1. Discharge of waste water at noon.

At night, we sample one from raw water at 21:00 and another from polluted water in factory at 21:10.

At night the perforated pipes, small vehicles in the 2nd, 3rd, 4th, 5th, 7th flocculation reaction tanks, and the big vehicles in sedimentation basin begin to drain mud. The 4th and 5th filter chambers begin to counter flushing.

The perforated pipes in the 2nd and 3rd flocculation basins begin to work at 23:53. Each time 2 perforated pipes are used to work. The total time is 12 minutes, and it spans from 23:53 to 00:05. Then the vehicles in the 2nd and 3rd reaction filter chambers begin to drain mud. Each time 2 small vehicles and 2 big vehicles work together as a group. The total time is 102 minutes, and it spans from 00:05 to 01:46.

The time span of perforated pipes in the 4th and 5th flocculation basins to drain mud is from 01:46 to 01:58. The time span of vehicles in the 4th and 5th reaction sedimentation basins to drain mud is from 01:58 to 03:40.

The time span of perforated pipes in the 7th flocculation basin to drain mud is from 03:40 to 03:50. The time span of vehicles in the 7th reaction filter chamber to drain mud is from 03:50 to 05:32.

There are 20 gridding in the 4th and 5th filter chambers. The counter flushing begins at 00:12. Each time a gridding is flushed and it lasts 12 minutes. All the gridding are flushed one by one. The time span to drain mud is from 00:12 to 04:12. Detailed time to drain mud refers to Figure-2.

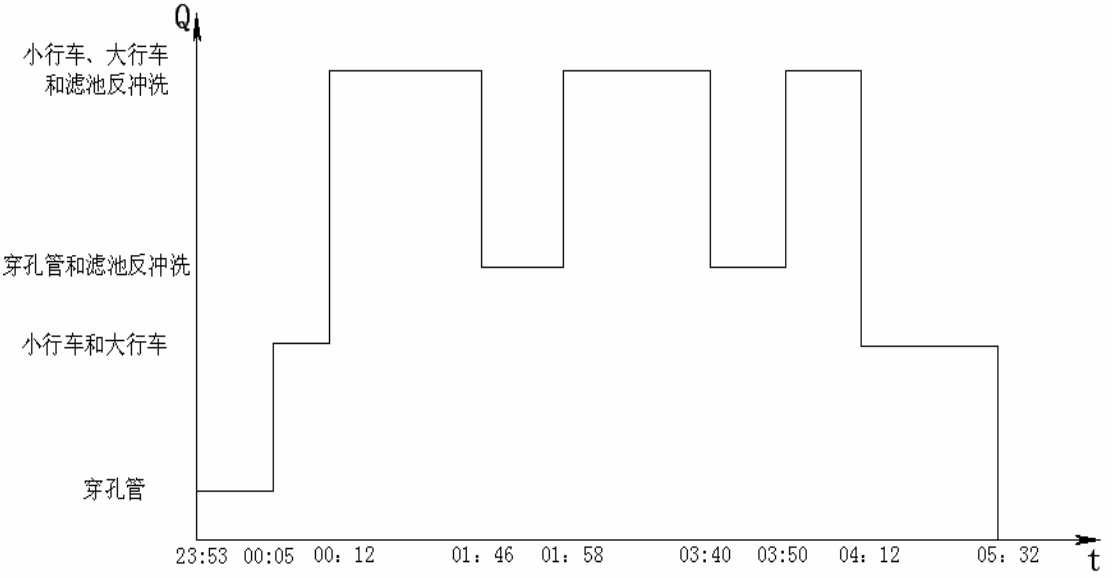


Figure-2. Discharge of waste water at night.

2.2 Testing of waste water quality

2.2.1 Purpose of testing

In the process of managing and controlling the pollution in water environment, we must test the water quality to learn the reasons behind the changing of water quality in water environment and its extent, especially the nature, contents and distributed state of pollutants which pose big threats in water [5].

We must test the waste water quality in drains to confirm the main indicators of waste water quality in drains of water plant, have a good knowledge of the features of waste water quality, find out the relations of these indicators and decide one indicator to be the basis of later model of hydraulic mass transfer.

2.2.2 The items and methods of testing

The items of testing water quality were COD, Fe, Al, pH value, temperature and turbidity.

The methods of testing [6] were:

COD: potassium dichromate method; Fe: Ferro in spectrophotometer; Al: chrome azurol S; SS: gravimetric method ; pH value: exact pH test paper in situ measurement; Temperature: in situ measurement by thermograph; and Turbidity: direct measurement by nephelometer.

3. RESULTS AND DISCUSSIONS

Table-1 shows the test results of the quality of waste water.

Table-1. Test results of the quality of waste water.

Water	Sampling time	Water temp. (°C)	pH	Turbidity (NTU)	SS (mg/L)	COD (mg/L)	Fe (mg/L)	Al (mg/L)	Remarks
1	9:15	9.0	6.0	25.40	44.5	7.9	1.71	--	Raw water
2	9:25	9.5	5.5	20.53	34.75	22.2	0.73	--	Factory effluent
3	12:36	10.5	5.0	73.01	501	84.8	8.97	20.84	Drain mud by perforate pipes
4	12:42	10.5	5.0	326.3	3036.7	139.2	52.87	25.12	Drain mud by small vehicles(initial stage)
5	12:54	10.5	5.0	306.5	1292	95.6	27.33	24.12	Drain mud by small vehicles (final stage)
6	13:11	10.5	5.0	282.9	3563.3	236.4	80.89	55.76	Small vehicles (final stage) and counter flushing in filter chambers
7	21:00	10.5	6.5	27.62	51.8	6.8	1.51	--	Raw water
8	21:10	10.5	6.0	10.56	13.3	21.1	0.40	--	Factory effluent
9	23 55	10.0	6.0	132.3	681	47.2	11.97	9.02	Drain mud by perforate pipes
10	00:10	10.0	6.0	251.6	4391	221.8	94.12	20.19	Small vehicles and big vehicles (initial stage)
11	00:30	10.0	6.0	350.8	2328.3	86.7	31.96	16.81	Small vehicles, big vehicles (final stage) and counter flushing in filter chambers

After processing, the pollutants in raw water have been greatly condensed. Many indicators are as large as scores or even hundreds of times as the original. The chemical medicine used in purifying water also makes Fe increase a lot. For example, SS in waste water is 90 times as that in raw water, COD is 30 times, Fe is 58 times. It is obvious that the direct draining of waste water has an influence on the environment.

The contents of Fe are much higher in raw water of Hanjiang, which is the source of drinking water. Two test results are 1.71mg/L and 1.5mg/L, which surpass the requirement of the standard of drinking water source that the density of second-rate water quality dissolved Fe should not bigger than 0.5mg/L.

Reasons: Raw water contains much mud and sand, which is adhered by Fe. When tested, the water contains mud and sand is boiled and then filtered. This dissolves and deoxidizes Fe which adheres to mud and sand. The testing result is the total sum of Fe in the water and Fe which adheres to mud and sand. So the contents of Fe in the water are over proof.

Figure-3 shows the relation between turbidity and SS.

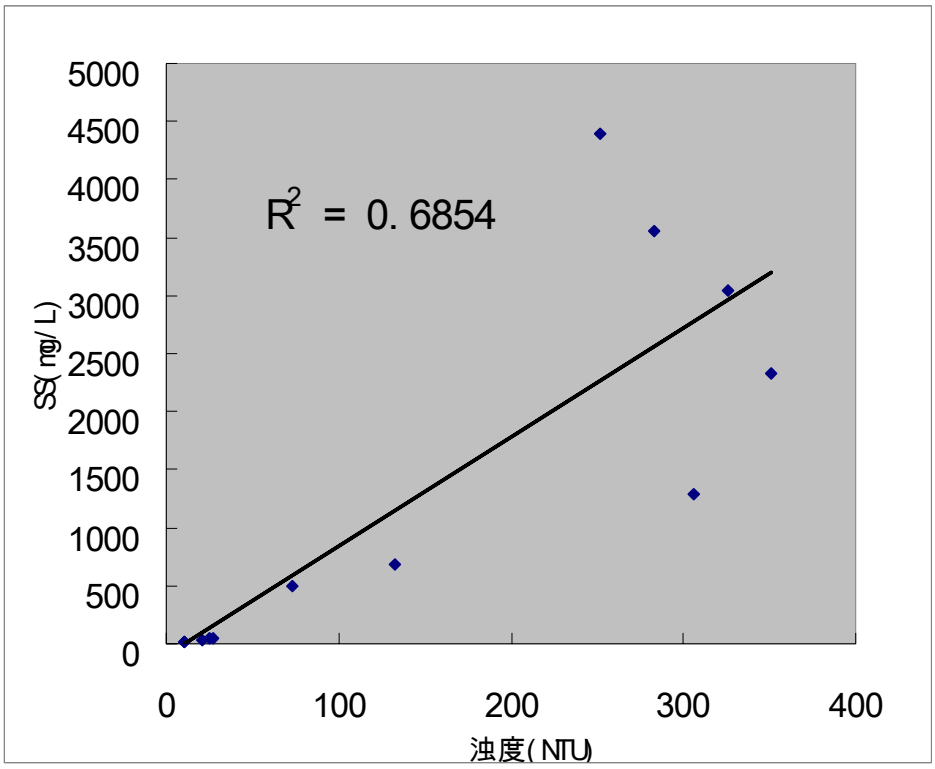


Figure-3. Correlation analysis of turbidity and SS.

From Figure-3, we can see that there is no linear relation between SS and turbidity. Only when SS and turbidity are relatively low, there is similar linear relation.

Reason: Nephelometer is a kind of optical instrument to measure turbidity by the intensity of scattered light which is formed when the light source getting through the tested water. It can efficiently test the impurity grains that within the scope of grain diameter of colloid.

Because of variability of the size, component, shape of the suspended grains in waste water, the turbidity value can not be directly converted into SS value (mg/L) by a certain fixed ratio.

Figure-4 shows the relation between SS and COD.

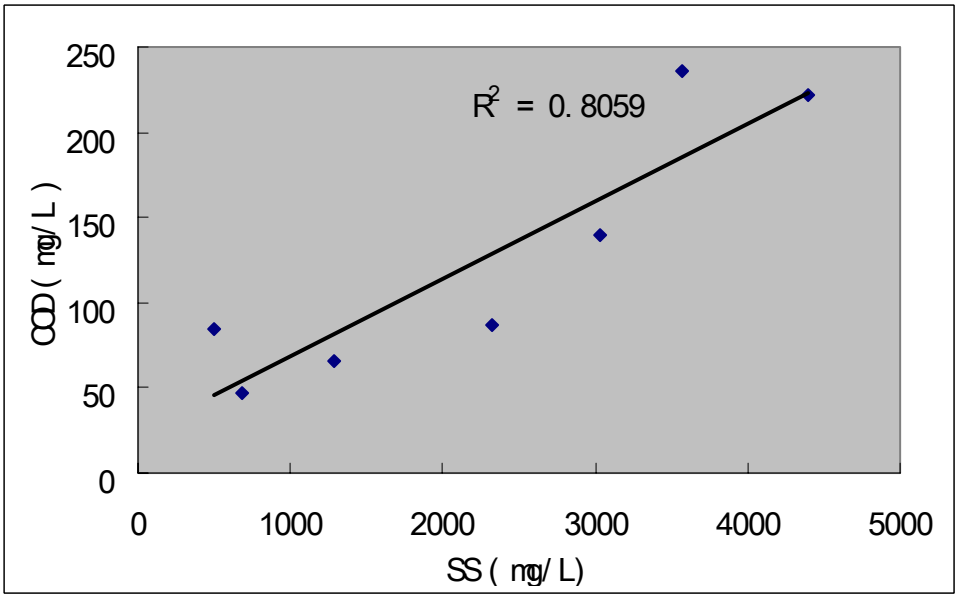


Figure-4. Correlation analysis of SS and COD.

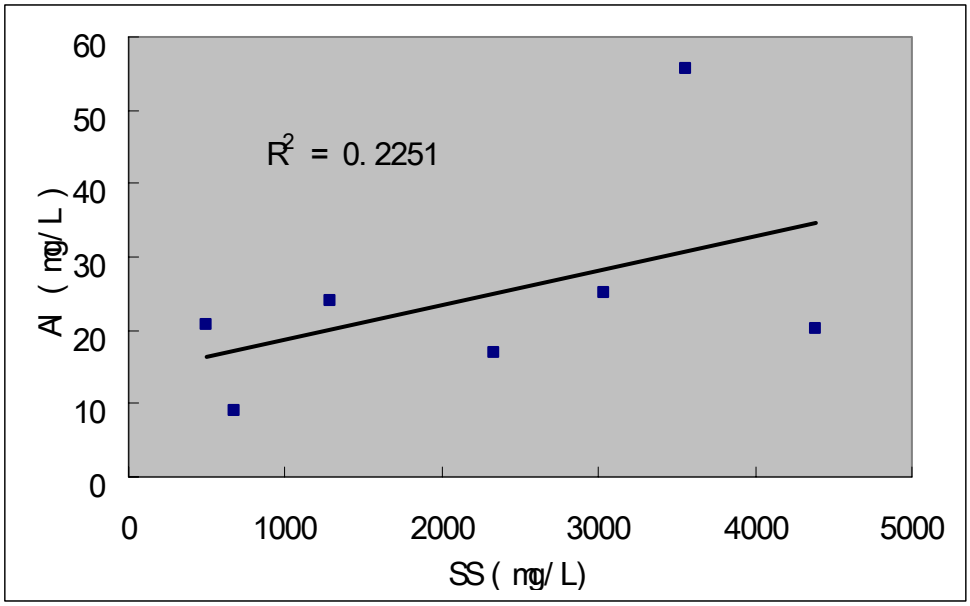


Figure-5. Correlation analysis of SS and Al.

Figures 5 and 6 show the relation between SS and Al and SS and Fe, respectively. From Figures 4, 5, and 6, it can be observed that there is a good linear relation between SS and Fe, not so good relation between SS and COD, bad relation between SS and Al.

Reason: it can further illustrate that much Fe adhere to suspended material and the contents of Fe grows as SS grows. Less COD adhere to suspended material. Because the easy changing of the contents of suspended material in waste water, there is not so good linear relation between COD and SS. Because of the inaccuracy of method to test Al, there is not so good linear relation between Al and SS, which is contradictory to the good linear relation between Fe and SS. The detailed analyzing reasons refer to the 7th item of the result analysis.

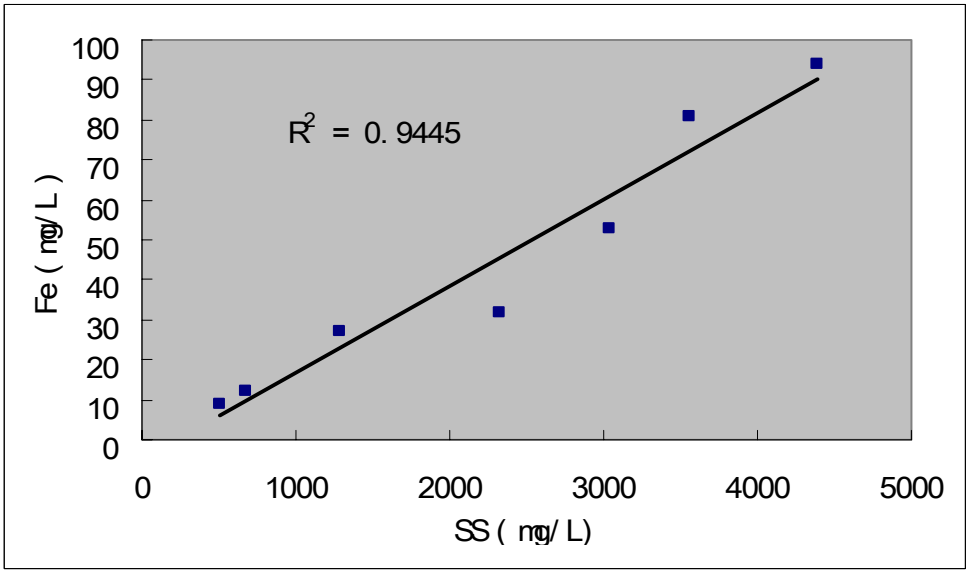


Figure-6. Correlation analysis of SS and Fe.

The water quality differs greatly at the beginning and at the end of time when vehicles to drain mud. For example, the SS of mud water drained by small vehicles at the beginning is 3036.7mg/L and the SS of that at the end is 1292mg/L. It also proves that the settling zone between flocculation basin and sedimentation basin can work in filtering process.

The flow rate of the counter flushing water is small when the gas flushing is happened in filter chamber, but it has a big influence on the overall waste water

quality. For example in the graph, the SS of mud water drained by small vehicles at the beginning are 1292mg/L. But when it is mixed with flushing water of filter chamber, the SS has increased to 3563.3mg/L. So it also has a big influence on the water quality of drained mud water.

Figure-7 shows the relation between Fe and Al.

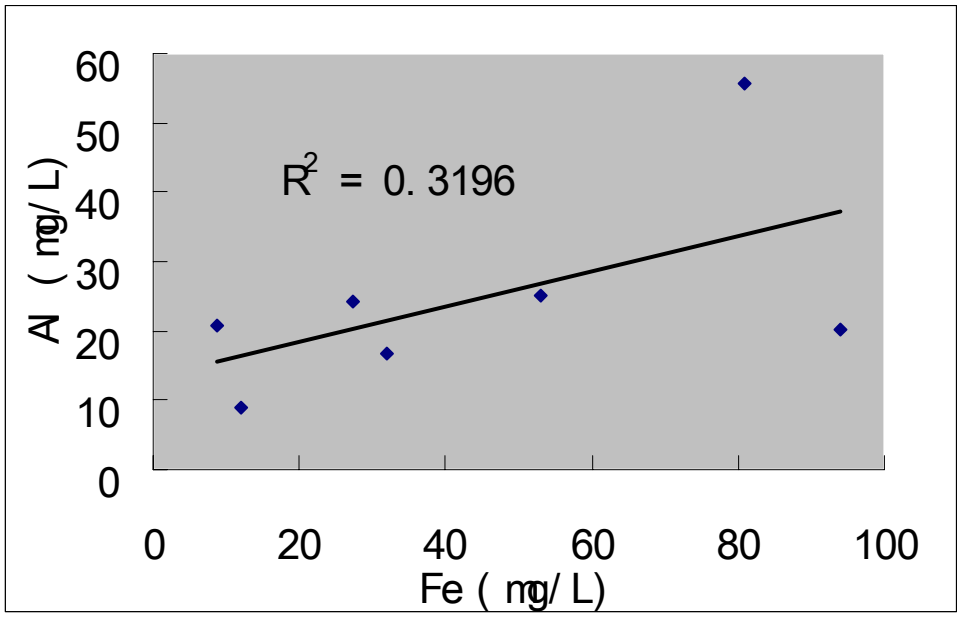


Figure-7. Correlation analysis of Fe and Al.

There is not so good linear correlation between Fe and Al (Figure-7). But theoretically speaking, as a component of coagulant PAFS, Fe should have an excellent linear correlation to Al. The specific reasons are as follows:

- The method to test Al is not perfect, which affect the accuracy of results. In the Water Quality Sanitation Regulation for Drinking Water (2001) issued by Health Department, the testing of aluminum can adopts the method of chrome azurol S, which is basically used in laboratory of water plant [7]. When the coagulant used in the processing craft of drinking water is aluminum potassium sulfate, this method can test the contents of aluminum accurately. But when the coagulant is polymeric aluminum potassium sulfate (PAFS), there is a big error. Because PAFS is an inorganic material aluminum potassium sulfate, the form of aluminum in PAFS and that in aluminum potassium sulfate differs substantially. Nowadays the testing of Al has no standard method promulgated by our country to consult.
- There is more Fe (1.71mg/L) in raw water; the contents of Al in raw water are nearly neglectful. This also affects the linear relation between the Fe and Al to a certain extent.

The factory effluent of Zongguan water plant can not meet the standard of discharging. According to The Overall Sewage Discharging Standard issued by our country, in the third-rate discharging standard, the SS should not bigger than 440mg/L [8]. So the waste water needs to be processed before being discharged. We recommend the method mentioned in 1.5 section, namely, the counter flushing water in filter chambers and the mud water in sedimentation basins should be processed independently or if the sewage treatment plant in the neighborhood can bear the burden of processing the waste water form water plant, water plant can filter and precipitate the waste water and then discharge the supernatant fluid into sewage treatment plant.

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