WaQuAC-NET Newsletter
Water Quality Asian Cooperation Network

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For Safe Water, Do Network.

Special Issue:

the Flood Crisis in Thailand

The steps of enhancing customer to know what Bangkhen Water Treatment Plant did for Water Quality Management in the flood crisis 2011, the Metropolitan Waterworks Authority, Bangkok Thailand

Ms. Nisapas Wongpat
Mr. Somsak Passananon
(MWA:Metropolitan Waterworks Authority, Thailand)

1. Summary

The vast flood crisis to central area of Thailand was the unprecedented situation which affected millions of people much more than anyone can expect. Bangkhen Water Treatment Plant, the biggest water treatment plant in Thailand, which supplies 3.6 million m3/d for nearly 10 million people living in 3 adjoining provinces including Bangkok, the capital city, has faced the flood crisis with the full team of experienced staff, retired employees and volunteer from both public and private sectors. With the great efforts of all corresponding working staff, we could pass that critical incident finally. Moreover during the steps of solving water quality problems which had become slightly yellowish in color and smell with some strong chlorine for a couple weeks, the Metropolitan Waterworks Authority (MWA) concerned that the most important step to obtain the acceptance from people in serviced area was to inform them of what has happened in water treatment plant.

<Key words>

Flood Crisis 2011, Bangkhen Water Treatment Plant, Water Quality Management

2. Introduction

Water flows through the heart of the community, agricultural and industry area, thus water quality of water source for Bangkhen Water Treatment, the biggest water treatment plant for a capital city, Bangkok was not normal. The Bangkhen Water Treatment Plant relies on open canal to transmit raw water from Chaophraya River to the treatment plant. This canal have been infiltrated and contaminated by the massive scale of flooding. MWA used a combination of effective methods to maintain the quality level of the WHO guidelines for drinking water. The important thing which MWA had to do simultaneously with the method of upgrading water quality was the step of enhancing customer to know what the treatment plant was doing for the water quality management.

3. Methods

MWA then distributed information that the first thing for MWA to do was the investigation for water quality assessment to answer what affects quality of tap water. We found that the flood through the area affected an increase of organic matter and suspended solids in raw water. So MWA intended to examine the factors that would affect health, including heavy metals, pesticides, as well as various pathogens. While waiting for the result, MWA took up oxygen in the water all the time. After monitoring and evaluating the raw water situation, MWA customized and added a special treatment to fix the problem for changing water quality as follows.

1) Aeration to maintain dissolved oxygen level. Inhibit occurrence of spoilage of water. Prevent odors from H_2S (hydrogen sulfide), NH_4 (ammonia) as well as reduce the amount of organic matter, color and some metals' parts that can be converted to oxide so as to let them settle in the canal.

2) The addition of potassium permanganate, the same way that we use to wash vegetables for daily consumption which The World Health Organization recommends that the chemicals used to solve the problem of water contamination by organic substances. Potassium permanganate ($KMnO_4$) was added to react (oxidize) with some heavy metals to precipitation and oxidizes organic compounds of large molecules into smaller molecules which are much ease of removal. Moreover the problem of Trihalomethanes will not exist through the process when added to chlorine.

3) The addition of activated carbon, which is highly effective in adsorption of organic compounds, heavy metals, colors and smells.

4) The addition of pre-chlorine to reduce the metals, organic matter and eliminate micro algae in the water.

5) The process of sedimentation with increase of the amount of alum, PACl (poly aluminum chloride) and coagulant aids polymer.

6) The addition of intermediate chlorine to reduce the amount of organic matter and algae efficiently

7) Rapid dual-media Sand Filter to clear the water to satisfy the WHO guidelines.

8) The final step is the post-chlorination to kill all germs. In addition to the amount of free residual chlorine outstanding for getting rid of germs at the end of the pipe away from the water plant, MWA increased supply of liquid chlorine to the water pumping station. For the purpose to raise the level of free chlorine residual in all areas, no matter how far, with not less than 0.2 mg / l, which is adequate to cope with the disease that may be slipped into the plumbing system in the future more effectively.

At this point, we finally ensure that the water quality problems of tap water through various processes and all disadvantage at every point are solved to meet the World Health Organization's drinking water safe from germs and contaminants that are harmful to health, MWA enhance the confidence of consumers by recommend consumers to boil water at 100 degree Celsius not less than 3 minutes in an open lid container, to keep away odors in water.

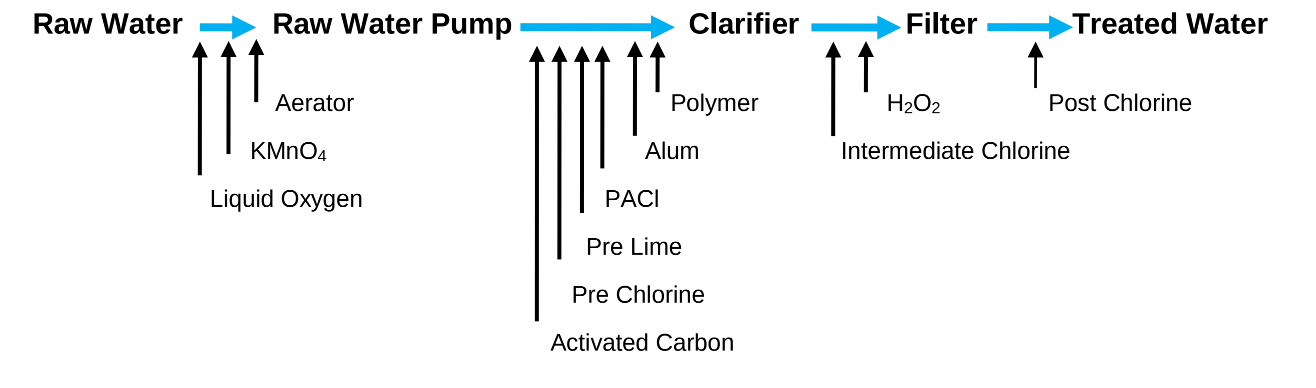
In addition, MWA raised people's awareness not to forget that floods may affect water pumps and water tanks in household. Some suffered water tanks and/or water pumps are likely to be highly contaminated of water inside. Color, odor problems and diseases, as well as other contaminants may occurs, while some customers may not know these are problems derived by pumps / water tanks of their own and may misunderstand them as problems of water supply. Therefore, to avoid problems that would result from such case, we announced to the customer, water from contaminated pumps and water tanks can't be used.

Chemical Dosage

(Average dosage in the flood crisis)

$KMnO_4$	2.0	mg/L
Polymer	0.04	mg/L
Aluminum Sulfate	73	mg/L
PACl	31	mg/L
Pre Lime	2.0	mg/L
Pre Chlorine	3.0	mg/L
Intermediate Chlorine	3.0	mg/L
Post Chlorine	5.0	mg/L
Activated Carbon	6.0	mg/L
H_2O_2	1.5	mgt/L

Chemical Dosing Point for Water Quality Control in the Flood Crisis of Bangkhen Water Treatment Plant



4. Conclusion

There are many steps to achieve the effective water quality management during the flood crisis 2011. The key of success is not only water treatment plant processes and water quality itself. It includes measures to resolve issues and performance of public services in the responsible area. To increase trust and reminded the public aware of the importance of water quality impact. And we are also reminded the main tasks of the Metropolitan Waterworks Authority. "Quality Water to the Quality life"

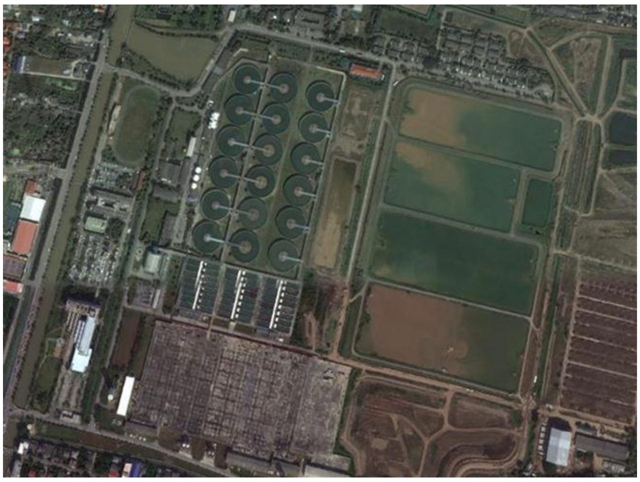


Figure 1.2 Bangkhen Water Treatment Plant; capacity 3.6 million m^3/day

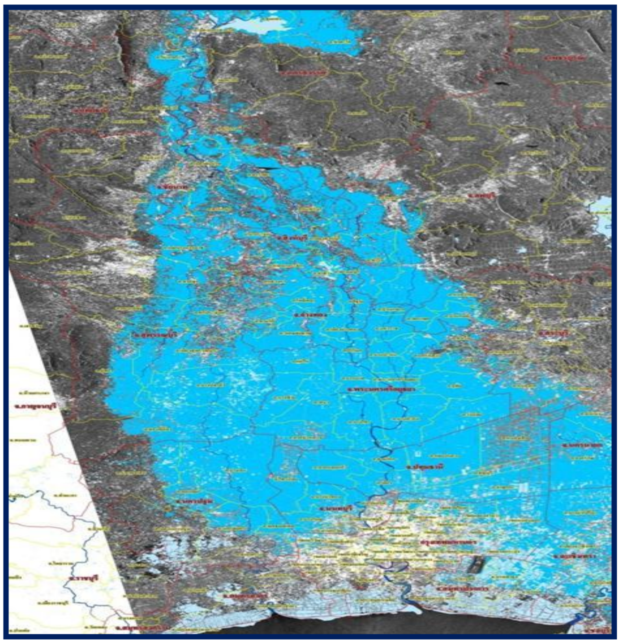


Figure 1.1 Massive scale of Flood attack Bangkok; blue color shows the flooded area

Flood in Thailand
Activity Report of Japan Disaster Relief
～ Power of MWA and friendship ～

Mr. Shingo HAYASHI;
Osaka Water Supply Authority

Four staff of Osaka Water Supply Authority were dispatched to Metropolitan Waterworks Authority (MWA) in response to the flood disaster in Thailand. I was dispatched as a member of the second team for two weeks from November 6 to 20, 2011 with my former colleague, Mr. Odawara. (The first team: Mr. Morita, Mr. Koseki)

Construction of protective barrier for receiving panel in WTP

Concerning damage by the flood, the Bangkhen Water Treatment Plant was not affected although it was partly inundated for a short time. The treatment plant was strictly protected with the treble barrier around; in addition, special barrier was constructed in the plant so that electric power receiving facility was protected.

Visit to Mahasawat WTP
(Center; Mr. Tawatchai, Chief of the WTP)

On the other hand, the Mahasawat Treatment Plant, located in the right bank of Chaophraya River, was affected by the flood; water level in the plant was up to nearly 1 m. However, important facilities were protected by maximum effort as drainage using pump. Consequently, plant operation was not affected except temporal reduction of supplying water quantity.

Main water quality problem was color and odor (e.g. musty odor); the cause of musty odor was assumed to be two compounds: 2-methylisoborneol and Geosmin, due to the species of algae.

To secure safety of supplying water, MWA was conducting analysis at full power by increasing frequency of testing. Every day testing results of harmful compounds such as heavy metals and flash report on chemical dosage were provided to us as well as basic water quality data (turbidity, color, residual chlorine, etc.).

MWA made every effort to treat the deteriorated raw water; coagulant (alum, PAC) and chlorine were applied at higher doses than usual. Powdered activated carbon and potassium permanganate were also added; moreover, aeration was performed to increase dissolved oxygen of raw water. Jar test was conducted every four hours to investigate optimal treatment conditions.
Because there was information that water from the flooding area might enter the raw water canal, our primary concern was how to remove harmful substances in case they were detected. Fortunately, raw water quality improved gradually since then, toxic substance had not been detected and tap water quality had always met WHO guideline values sufficiently.

I was impressed by the MWA's various effort against flooding, and recognized MWA's technical capabilities and strong internal control.
We surveyed the upper stream of raw water canal as far as we were able to approach, and investigated the situation of the facilities such as pumping stations.

During our stay, dozens of MWA staff supported our activities; we were deeply moved by their hospitality every day. Many staff of MWA had really suffered damage from the flood, and some of them had been staying at the office for a few weeks. In the Bangkhen Treatment Plant, citizen volunteers were making life water bags which would be sent to the evacuation center. Some staff engaged in the activities until midnight after work. In this way, all the staff and citizens put their mind together to stand against the disaster.

Before leaving MWA, we submitted "suggestions" regarding risk management on water supply. Equipment: drainage pump and air compressor, etc., were supplied as emergency relief by JICA.

We had strong feeling of togetherness because we shared problems with each other facing the difficult reality. So now I feel as if MWA were a close water utility in Japan. At the Great East Japan Earthquake, Japan received big support from the government of Thailand. I hope both countries will continue to value a good relationship in the future to support each other in emergency situations.

Mr. Hayashi and Mr. Odawara

[Overseas report]

Report from Bhutan no.2

Mr. Yasuyuki KITAHARA
JICA Volunteer

1. Introduction

It has already passed one year and 11 months since I was dispatched to Kingdom of Bhutan as Japan Overseas Cooperation Volunteer (JOCV). Activity period as JOCV is basically 2 years. However, my term was extended 6 months until July 2012 because of the request by myself and assigned department of Bhutan side. Therefore, I think I can put more focus on my activities.

Request from Bhutan side to my activities are, 1) Solution of clogging the water pipe due to contain lime component in the water source, 2) Preventive measures against burst of water pipe due to pipe freezing during winter season. These two points are my main activities. I am coping with these challenges by business trips because these problems happen in rural area.

I would like to report about my activities by divided each problem.

2. Removal of lime component

I have never experienced about removal of lime component in Japan, so started collecting information at first. Including lime component in the water means "hard water". I thought that if water can be changed to "soft water", this means that lime component would be removed to some extent. "Hard water" is changed to "soft water" by using chemicals or ion exchange in Japan. However, it is difficult to buy chemicals in developing countries, and also even if advanced facility is constructed, it would become useless due to not proper maintenance.

Therefore, I proposed construction of simple slow sand filter. I thought that it might not remove completely 100% of lime component from the water but this filter can remove pathogenic bacteria and turbidity also. Bhutan, especially in rural area, water is distributed directory from water source without any purification system. I introduced up-flow tank as pre-treatment, and designed filter basin based on served population.

September 2011, I implemented the survey and design, then proposed slow sand filter as pilot project in Pemagatshel District.


Population is about 2000


Water source


Planned area for slow sand filter


Meeting in April, 2011


Starting the construction of three up flow tanks as pretreatment in May, 2011

But this project was canceled.

October 2011, I proposed slow sand filter as pilot project in Sarpang District.

After construction, I brought sample water to laboratory.

Result of water quality analysis;

(Hardness) Water source: 62.294, filtered water: 30.771

I think this system showed good result because it succeeded in reduction of calcium (Ca), though hardness of raw water was not high level. Based on this experience, I would like to try this system in the area where hardness in water source is around 300. I cannot say that this slow sand filter can remove 100 % of lime component from the water, but I feel this result is good as first step for the next proceed. Since I took sample water in summer season, I would like to compare with the result in winter season.

As next step, I will find the improve points of this slow sand filter and make a manual for construction by Bhutan people themselves only. And I will select next area for construction.


Slow sand filter


Completion


Up-flow tank
Completed in August, 2011

3. Freezing protection Measures

Bhutan, especially in rural area, water supply is not served into the inside of house, and most of people use public tap (refer below picture).

This design is made by the central government and introduced to each province. Steel pipe, fitting and tap are made in India. Quality of materials can definitely not say good. This design does not cause any problems, if tap is constructed at warm place throughout a year. But it is damaged by freezing and would burst at the highland where temperature becomes below zero in winter. Therefore, I designed public tap with cold weather specification for the freeze prevention of pipe by using materials which can be obtained in Bhutan.

Materials used

Thermal insulation materials:
Polystyrene sheet, Vinyl sheet, Aluminum sheet, Vinyl tape

Type I: Lagging existing design facility by thermal insulation materials, then construction.

Type II: Introduction of two valves in the underground based on essential of Antifreeze valve, then discharge water in the pipe during the night. Lagging is implemented to the pipe in the underground and concrete.

Lagging

Completion of Lagging

Six public taps with cold weather specification were constructed at Haa District and Gasa District each. I have a plan to monitor them and find out improvement points after winter season, then prepare manual and lead to future.

Introduction of New Members

- Mr. SRISATIDNARAKUL Narongrit (Thailand)
- Mr. Noboru OZAKI (Japan)
- Mr. Ken KOSEKI (Japan)
- Mr. Yasuhiro FUJINO (Japan)
- Mr. Mitsuhiro FUJITANI (Japan)
- Mr. Shingo HAYASHI (Japan)

We welcome new member any time.
Please contact us

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Topic: Flood in Thailand

WaQuAC-Net Office
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URL: http://www.waquac.net
Next Activity
May. 2012 Newsletter No.14 (Japanese)
June 2012 Newsletter No.14 (English)

Member introduction

Mr. Mon Tito

(Phnom Penh Water Supply Authority;
PPWSA, Cambodia)

I graduated from the faculty of food and chemistry in the Institute of Technology of Cambodia and was employed in PPWSA, 2002. Now I am working for Churouy Changwa WTP as a water quality analyst. I studied General Management at Build Bright University while working. My family consists of my wife, Chea Soneda who got married with me in 2007 and two-year old son, whose name is Toti Moriyo.

In June, 2009, I came to get JICA training course. I stayed in Osaka city for participating a training course of "Maintenance and Operation of Urban Water Supply Systems". During my stay in Osaka, my son was born. I want to exchange technical information as a member of WaQuAC-NET.

The Party of Ashigaru

Shinichi SASAKI
Yokohama Waterworks Bureau

We had a welcome party of Mr. SAMRETH Sovithia (Deputy General Director Phnom Penh Water Supply Authority, Cambodia) and Mr. TRUONG Cong Han (Manager of Planning Department, TT-Hue Construction and Water Supply Company, Vietnam) who visited Japan as panelist of "Second Seminar for Urban Water Service Management and Human Resource Development in Asian Region"

January 24 --- Mr. Sovithia (Cambodia), Mr. Han (Vietnam), Mr. Anh (interpreter), Mr. Matsui (JWWA), Ms. Yamamoto (JICA) and Mr. Sasaki (Yokohama WWB) 7 in total.

The 3rd party of Ashigaru (please see newsletter Vol. 12 for the previous party). We went to local bar "Ichinokura" where we can enjoy Japanese sake of Miyagi brewery in reasonable price. The bar is rather large but has pillars and window frames with look of age, and separated into small compartments, which can satisfy the criteria of venue of Ashigaru party; small, dark and dingy.

Cheers with beer. Starting from "Mot, Hai, Ba (1, 2, 3 in Vietnamese)", we continued to drink by "Mui, Pii, Bai (in Khmer)" and "Neung, Song, Saam (in

From left; Sasaki, Matsui, Tanaka, An, Hang, Sovithia, Yamamoto

Thai)" came out, too, which started our funny party! Ms. Yamamoto and I sat with Mr. Sovithia and Mr. Tanaka sat with Mr. Hang and Mr. Anh, and Mr. Matsui sat in the middle and drank with everyone with a smile. When we went on chatting with exchanging many glasses, Mr. Han straitened himself with his glass up and started reading a Chinese ancient poem (?) solemnly. According to Mr. Anh's interpretation it meant "Fish live in water, bird live in sky, animal live in land and …". Though I was too drank to catch the last part of the poem unfortunately, it was so cool of Mr. Hang to make a toast by traditional poem! Now I remember this poem seem to be similar to a poem on an inscription of King Ramkhamheang the Great, Thailand.

Well, it was OK. All really enjoyed, and food and drinks were nice.

The Party of Ashigaru … Plus

(January 26 with Mr. Sovithia, Ms. Yamamoto and Mr. Sasaki)

We little richly selected Shabu-Shabu (Japanese style pork-hotpot) as a farewell dinner. Mr. Sovithia and I were so attracted to waitresses in nice Kimono. While drinking and eating Shabu-shabu which waitress cooked for us, we talked on the seminar, shopping, family, and voluntary activities of H.E. Ek Sonn Chan (General Director, Phnom Penh Water Supply Authority). On weekends, he goes to rural .area and advices farmers on rice cultivation. He instructs anything; seeding, planting and harvesting so he is really esteemed by the farmers and now followed by his staff one after the other. Ms. Yamamoto and I were so impressed by this story and we dreamed of accompanying him to walk around Cambodian villages some day.

We parted reluctantly each other because Mr. Sovithia would leave Japan on the early morning of the following day.

Question & Answer Corner

We welcome any opinions, and questions to this Q & A Corner.

Q: Could you tell me quality analysis method of solid PAC?

I would like you to know checking method of quality of PAC. We don't have experience for it. And we are planning to use PAC instead of Aluminum Sulfate.

(Mr. H, Mr. T, Ms. S, Cambodia)

** The followings are answered by Mr. Sasayama, and Mr. Kudo and arranged by Ms. Yamamoto responsibly.*

A: Waterworks bureaus in Japan use liquid PAC. Quality of liquid PAC and the check method are regulated by "Japan Waterworks Association Standard –JWWA K 154 Polyaluminum chloride". This Japanese standard cannot be applied to solid PAC. Mr. Sasayama modified it for analytical method of solid PAC. Mr. Kudo checked it. Mr. Sasayama's analytical method is written in Annex-1. And also Quality of PAC (liquid) regulated by JWWA K154 is written in Annex-2

➢ ***We considered how you check solid PAC quality firstly, as following.***

1. What is the quality check of PAC?

1) Verify the sufficient coagulation result
2) Verify that the content (by percentage) of aluminum oxide written on the purchased PAC is constant anytime.
3) Verify that harmful substances are below acceptable value of drinking water quality standard.
4) When PAC is dissolved in water, verify there are no impurities which cause the clogging of the pipe.

Through the periodic check above 1)~4), judge whether the purchased PAC has stable quality or whether some changes happened in the manufacturing process.

2. Check method

1) Verify the sufficient coagulation result

Dissolve a fixed amount of PAC into water and make fixed concentration of PAC solution. Change the dosing rate of the PAC solution and verify whether to be able to find most effective dosing rate (see turbidity of treated water) by jar-test.

＊ At first, how much should PAC concentration be as fixed concentration ?

Since it is supposed that a fixed concentration of PAC is written in standard directions for use to solid PAC which purchased, just follow it. If the standard direction is not written, basically, take 2~10g of solid PAC and dilute it by water as check sample. Solid PAC is hard to dissolve in water, therefore concentration of aluminum oxide of the sample solution will be about 1~2%. Comparing with Japanese case, concentration of aluminum oxide will be 1/10 ~ 1/5 times. Because the result of coagulation effect depends on amount of dosing of aluminum oxide, the dosing rate of PAC solution will be 5 to 10 times higher than Japanese case. It may be easy for small water treatment plant to control dosing of PAC.

＊ PAC has excellent characteristic which the range of optimum dosing rate is wider than aluminum sulfate.

It means that even if turbidity of raw water changes widely, it is easy to deal with it. It will become easy to manage turbidity of treated water at the WTP. It is important to do Jar-test periodically, to verify optimum dosing rate and to check quality of PAC products.

2) Verify that the content (by percentage) of aluminum oxide written on the purchased PAC is constant anytime.

＊There are several verification methods. Here, three of them are explained.

(1) Carry out the jar-test by using same concentration's aluminum oxide solution, same dosing rate and same sample water. Then verify to result the same coagulation effect. If the result is not same, content of aluminum oxide in the purchased solid PAC has variation. It means the quality of PAC has problem.

(2) Make a solution of fixed concentration of aluminum oxide. Then analyze amount of aluminum oxide. There are several analytical methods. Titration method which was modified based on JWWA K154 by Mr. Sasayama in Annex-1. In this case, it is assumed to use high quality reagents (reagent of JIS (Japanese Industrial Standards are used in Japan).

(3) As easy analysis, check aluminum concentration by Hach's spectrophotometer. First, ample is digested with acid as same as titration method and adjusted pH to recommended range in the Hach's instruction. Aluminum oxide content is calculated with the result of aluminum concentration. Then verify whether same amount of aluminum oxide contains anytime.

3) Verify that harmful substances** are below acceptable value of drinking water quality standard.

Even if the maximum possible dosing rate is used, treated water has to meet the drinking water quality standards.

4) When PAC is dissolved in water, verify there are no impurities which cause the clogging of the pipe.

Check the appearance and insoluble matters

5) Judge whether products are stable or some changes happened in the manufacturing process.

Big difference compared to normal pH is considered something happened in materials or manufacturing process.

** As harmful substances, followings are written in Japanese Standard.

Cadmium, Mercury, Selenium, Zinc, Arsenic, Hexavalent chromium

Annex-1

*Following analytical method is modified by Mr. Sasayama for solid PAC and confirmed by Mr. Kudo.

Analytical Method: Aluminum Oxide in Poly Aluminum Chloride

1. Principle

Polymerized aluminum is decomposed to aluminum ion with acid. Excess of disodium ethylene tetraacetate is added and aluminum chelate is produced completely. Then surplus of ethylene tetraacetate is obtained by titration of zinc solution with xylenol orange as the indicator.

2. Reagent

All reagents should be analytical grade.

(1) Nitric acid (1+12)

5mL of nitric acid (>62%) is diluted with 60mL of distilled water.

(2) 0.05mol/L EDTA solution

18.61g of disodium ethylenediamine tetraacetate dihydrate is dissolved in 1000mL of distilled water.

(3) Sodium acetate buffer solution

272g of sodium acetate trihydrate is dissolved in distilled water and its volume is adjusted to 1000mL.

(4) Xylenol orange solution (1g/L)

0.1g of xylenol orange is dissolved in distilled water and its volume is adjusted to 100mL.

(5) Standard solution of aluminum (1mg Al/mL)

1.000g of aluminum (>99.99%) is put into 100mL glass beaker. Small portion of nitric acid (1+1) is added. Then beaker is covered with a watch glass soon. The beaker is heated to react aluminum with acid completely. After cooled the beaker, the solution is moved into 1000mL volumetric flask and diluted to 1000mL with nitric acid (1+30).

(6) 0.02mol/L zinc solution

1.308g of zinc powder is put into 100mL glass beaker. 6 to 7mL of hydrochloric acid and small portion of distilled water are added. The beaker is heated to react zinc with acid completely. Then the beaker is heated more on water bath to evaporate water of the solution. After the solution nearly become solid, it is dissolved with distilled water. Then it is put into 1000mL volumetric flask and diluted to 1000mL with distilled water. 20mL of 0.05mol/L EDTA solution is taken in 200mL glass beaker. 2mL of nitric acid (1+12) is added Then steps **3**. (3) to (5) is operated. Titrated volume of zinc solution is $\mathbf{a_1}$. 20mL of aluminum standard solution (1mg Al/mL) and 20mL of 0.05mol/L EDTA solution is taken in another 200mL glass beaker. 2mL of nitric acid (1+12) is added. Then the beaker is covered with a watch glass and boiled for 1 minute. The beaker is cooled down to room temperature and steps **3**. (3) to (5) is operated. When titrated volume of zinc solution is $\mathbf{a_2}$, aluminum amount corresponding to 1mL of 0.02mol/L zinc solution is obtained with the following equation.

$$f_1 = \frac{0.001 \times 20}{a_1 - a_2}$$

where,

f_1: aluminum amount corresponding to 1mL of 0.02mol/L zinc solution

3. Analytical procedure

(1) About 3g of solid poly aluminum chloride is weighed with the digit of mg. It is dissolved with distilled water. The solution is put into 500mL volumetric flask and diluted to 500mL with distilled water.

(2) 20mL of sample solution is put into 200mL Erlenmeyer flask. 2mL of nitric acid (1+12) is added to make pH 1 to 2. The beaker is covered with a watch glass and heated. The solution is boiled for 1 minute then cooled. 20mL of 0.05mol/L EDTA solution is added.

(3) Sodium acetate buffer solution is added till pH of the solution, measured with thymol blue pH indicator paper, reach to 3. Then the solution is boiled for 2 minutes.

(4) After the solution is cooled, about 10mL of sodium acetate buffer solution is added to change pH 5 to 6. 2 to 5 drops of xylenol orange solution is added.

(5) The solution is titrated with 0.02mol/L zinc solution until the color is turned to light red.

(6) 20mL of 0.05mol/L EDTA solution is put into 200mL Erlenmeyer flask. 20mL of distilled water and 2mL of nitric acid (1+12) are added. Then steps (3) to (5) is operated.

4. Calculation

Aluminum oxide (%) in the sample is obtained with the following equation.

$$A = \frac{1.8895 \times (b_2 - b_1) \times f_1}{S \times \frac{20}{500}} \times 100$$

where,

A (%): aluminum oxide content in the sample

1.8895: coefficient of aluminum oxide corresponding to aluminum

f_1 (g): amount of aluminum corresponding to 1mL of 0.02mol/L zinc solution

b_1 (mL): titrated volume of 0.02mol/L zinc solution for the sample solution

b_2 (mL): titrated volume of 0.02mol/L zinc solution in the step **3**.(6)

S (g): weight of sample

Annex-2

Reference

Table 1 Quality of PAC JWWA K 154

Type	Liquid type*
Appearance	Transparent or yellow tinted pale brown liquid
Specific gravity (20℃)	1.19 or more
Aluminum oxide (AL2O3) (wt%)	10-11
pH (10g/L solution)	3.5-5.0
Sulfate ion (So42-) (wt%)	3.5 or less
Basicity (wt%)	45-65

This is a Japanese standard. The standards are intended for the products manufactured according to JIS (Japanese Industrial Standards.)

Since the products obtained by each country differ, we cannot say whether it is applicable as it is.

Mr. Kudo

Mr. Sasayama