

**J. TECHNICAL SPECIFICATION FOR SEWAGE AND SLUDGE  
INVESTIGATIONS**



## **J. TECHNICAL SPECIFICATION**

### **1. General**

The Works shall be executed and completed in accordance with the term, conditions and requirements of the Contract and Technical Specifications and under the supervision of the JICA Study Team (hereinafter called as the Engineer).

### **2. Scope of the Works**

The Works include sampling of water and sludge, the laboratory analysis of the water and sludge samples, sewage flow measurement and reporting of the analytical works.

- (a) Sewage sampling at Si Phraya and Huay Kwuang treatment works and subsequent Laboratory Tests, and Flow Measurement.
- (b) Sewage Sampling at drainage pipes and subsequent Laboratory Tests, and Flow Measurement.
- (c) Sludge Sampling at Si Phraya and Huay Kwuang sewage treatment works, and On-Nut and Nougkaem Night Soil treatment works, and subsequent Laboratory Tests.

### **3. Work Description**

#### **(1) Sewage Quality and Flow Rate Survey at Sewage Treatment Works**

Sewage sampling at Si Phraya and Huay Kwuang STW's inlet and outlet, respectively. (Total 4 locations)

Samplings are to be done in 1 day and 4 times per day, in dry and rainy seasons.

Water quality test items are BOD, SS and COD.

Water quality of Cd, Cr, Pb, Mn, Ni and Hg shall be tested at 4 locations (inlets and outlets of two STWs) only 1 time in each season.

Flow measurement shall be carried out at 2 (inlets only) locations, 4 times a day in each season.

For rainy days, time-wise flow measurement shall be carried out at 30 minutes interval for 2 hours in total. (which means 4 times measurement per day). The test has to be done in 2 locations.

For rainy days, time-wise sewage quality analysis shall be carried out at 30 minutes interval for 2 hours in total. (which means 4 times measurement per day). The test has to be done in 2 locations.

**(2) Sewage Quality and Flow Rate Survey at Drainage Pipes**

Sewage sampling and flow measurement in drainage pipes shall be carried out in the same manner as indicated in the previous section for Sewage Treatment Works.

The location of sewage sampling and flow measurement will be residential, commercial and mix areas. (The actual sites will be fixed by the Study Team at the time of surveying.)

Samplings are to be done in 1 day and 4 times per day, in dry and rainy seasons.

Water quality will be tested at 3 locations and test items are BOD, SS and COD.

Water quality of Cd, Cr, Pb, Mn, Ni and Hg shall be tested at 3 locations only 1 time in each season.

Flow measurement shall be carried out 3 locations, 4 times a day in each season.

For rainy day, time-wise flow measurement and water sampling shall be carried out at 3 locations at 15 minutes interval for 2.0 hours in total (totalling 8 times measurement per location). The water quality parameters will be BOD, SS and COD.

**(3) Sludge Quality Survey at Sewage Treatment Works and Night Soil Treatment Works**

Sludge sampling at Si Phraya and Huay Kwang WTP's and On-Nut and Nongkaem sludge treatment works. (Total 4 locations)

One sample will have to be tested each locations, in dry and rainy seasons.

Sludge quality tests are to be carried out on twenty three quality items as shown below.

- |                            |  |
|----------------------------|--|
| 1. Moisture content        | 13. Copper                               |
| 2. Total solid contents    | 14. Lead                                 |
| 3. Volatile solid contents | 15. Manganese                            |
| 4. Nitrogen contents       | 16. Nickel                               |
| 5. Carbon contents         | 17. Zinc                                 |
| 6. Sulfur contents         | 18. Mercury                              |
| 7. Phosphorus contents     | 19. Calorific value                      |
| 8. Chlorine contents       | 20. Specific gravity of fixed solids     |
| 9. Alkalinity              | 21. Specific gravity of volatile solids. |
| 10. pH                     | 22. Grain size distribution              |
| 11. Cadmium                | 23. Potassium                            |
| 12. Chromium               |  |

A summary of work description is given below.

Item	Number of test	Parameter	Quantity
Sewage Sampling at STP's and Testing	4 Locations x 1 day x 4 times a day (every 6 hours) x 2 seasons	BOD SS COD	32
	4 Locations x 1 day x 1 time x 2 seasons	Cd Cr Pb Mn Ni Hg	8
Flow Measurement at STP's	2 Locations x 1 day x 4 times a day x 2 seasons	Flow	16
Rainy Day Time-wise Sewage Sampling at STP's and Testing	2 locations x 1 day x 4 times (30 min. interval)	BOD SS COD	8
Rainy Day Time-wise Flow Measurement at STP's	2 locations x 1 day x 4 times	Flow	8
Water Sampling from Drainage Pipes and Testing	3 locations x 1 day x 4 times a day x 2 seasons	BOD SS COD	24
	3 Locations x 1 day x 1 time x 2 seasons	Cd Cr Pb Mn Ni Hg	6
Flow Measurement of Drainage Pipes	3 locations x 1 day x 4 times a day x 2 seasons	Flow	24
Rainy Day Time-wise Water Sampling and Testing of Drainage Pipes	3 locations x 2 seasons x 8 times (15 min. interval)	BOD SS COD	48
Rainy Day Time-wise Flow Measurement of Drainage Pipes	3 locations x 2 seasons x 8 times (15 min. interval)	Flow	48
Sludge Sampling from Sewage and Sludge Treatment Works	4 locations x 1 day x 1 times x 2 seasons	As indicated in the earlier section (22 items)	8

## **Technical Specification for Additional Survey in Wet Season**

- 1. Night Soil Sludge Sampling and Analysis**  
1 sample from Nong Khaem and On-nut NSTPs on 3 different days to be analysed for 8 heavy metal items (Cd, Cr, Cu, Pb, Mn, Ni, Zn, and Hg).
- 2. Wastewater Sludge Cake Sampling and Analysis**  
1 sample from Si Phraya WWTP and Huay Kwuang Community Plant on 3 different days to be analysed for 8 heavy metal items (Cd, Cr, Cu, Pb, Mn, Ni, Zn, and Hg).
- 3. Wastewater Sampling and Analysis at WWTP during Normal Weather**  
Samples taken from Si Phraya WWTP inlet and outlet at 2 hour interval over 24 hours on 3 different days to be analysed for TSS, VSS, BOD and COD. Samples to be taken over 24 hours shall be composite.
- 4. Wastewater Sampling and Analysis at WWTP during Storm Events**  
Samples taken from Si Phraya WWTP inlet at 15 minutes interval over 3 hours starting after the storm begins on 2 different days to be analyzed for TSS, VSS, BOD and COD.
- 5. Wastewater Sampling and Analysis for Drainage Pipes during Normal Weather**  
Samples taken from the 1 sampling manhole in Si Phraya, Yannawa, Din Daeng, Ratanakosin, Ratburana and Nong Khaem catchment areas at 2 hour interval over 24 hours on 2 different days to be analyzed for TSS, VSS, and BOD.
- 6. Wastewater Sampling and Analysis for Drainage Pipes during Storm Event**  
Samples taken from the 1 sampling manhole in Si Phraya, Yannawa, Din Daeng, Ratanakosin, Ratburana and Nong Khaem catchment areas at 15 minutes interval for 3 hours on 2 different days to be analyzed for TSS, VSS, BOD, and COD.

**Additional Wastewater and Sludge Survey Quantities**

Item	Location	Number of Sampling per Day	Sampling Day	Total No. of Sampling	Number of Samples for Test	Number of Test Item	Total No. of Tests	Test Items
1. Night soil Sludge Sampling and Analysis	Nong Khaem NSTP	1	3	3	3	3	24	Heavy Metal <sup>1)</sup>
	On-Nut NSTP	1	3	3	3	3	24	Heavy Metal <sup>1)</sup>
2. Wastewater Sludge Cake Sampling and Analysis	Si Phraya WWTP	1	3	3	3	3	24	Heavy Metal <sup>1)</sup>
	Huny Kwang Community Plant	1	3	3	3	3	24	Heavy Metal <sup>1)</sup>
3. Wastewater Sampling and Analysis at WWTP during Normal Weather (Inlet)	Si Phraya WWTP	12	3	36	Composite 3	4	12	TSS, VSS, BOD, COD
		12	3	36	Composite 3	4	12	TSS, VSS, BOD, COD
4. Wastewater Sampling and Analysis at WWTP during Storm Events (Inlet)	Si Phraya WWTP	12	2	24	24	4	96	TSS, VSS, BOD, COD
5. Wastewater Sampling and Analysis of Drainage Pipes during Normal Weather	Si Phraya	12	2	24	Composite 2	3	6	TSS, VSS, BOD
	Yannawa	12	2	24	Composite 2	3	6	TSS, VSS, BOD
	Din Daeng	12	2	24	Composite 2	3	6	TSS, VSS, BOD
	Ratburana	12	2	24	Composite 2	3	6	TSS, VSS, BOD
	Ratnakosin	12	2	24	Composite 2	3	6	TSS, VSS, BOD
	Nong Khaem	12	2	24	Composite 2	3	6	TSS, VSS, BOD
	Si Phraya	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Yannawa	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Din Daeng	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Ratburana	12	2	24	24	4	96	TSS, VSS, BOD, COD
6. Wastewater Sampling and Analysis of Drainage Pipes during Storm Events	Si Phraya	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Yannawa	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Din Daeng	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Ratburana	12	2	24	24	4	96	TSS, VSS, BOD, COD
	Ratnakosin	12	2	24	24	4	96	TSS, VSS, BOD, COD
<b>Total</b>				<b>396</b>			<b>928</b>	

Note: 1) Heavy Metal, Cd, Cr, Cu, Pb, Mn, Ni, Zn, Hg

**K. MINUTES OF TECHNICAL MEETINGS**

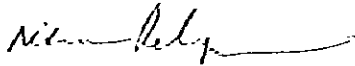


MINUTES OF MEETING  
ON  
INCEPTION REPORT  
FOR  
THE STUDY FOR THE MASTER PLAN  
ON  
SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED  
WASTEWATER REUSE  
IN  
BANGKOK  
IN  
THE KINGDOM OF THAILAND

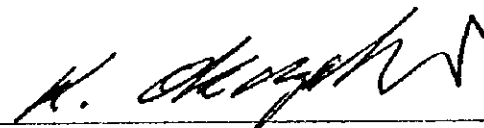
AGREED BETWEEN

THE BANGKOK METROPOLITAN ADMINISTRATION  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM

Bangkok, September 24, 1998

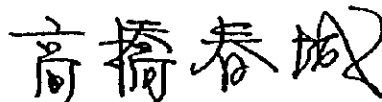


Mr. Nikhom Prachyanakorn  
Director General  
Department of Drainage and Sewerage  
Bangkok Metropolitan Administration



Mr. Keisuke Okazaki  
Leader of JICA Study Team

Witnessed by



Mr. Haruki Takahashi  
Chairman of Advisory Committee  
of JICA

## 1 Introduction

At the commencement of the Study for the Master Plan on Sewage Sludge Treatment / Disposal and Reclaimed Wastewater Reuse in Bangkok, meetings were held between the Bangkok Metropolitan Administration (BMA) and the Japan International Cooperation Agency (JICA) at the BMA 2 Building conference room, Bangkok, Thailand, on 22 and 23 September 1998. The list of attendants is given in Appendix 1.

The JICA Study Team submitted the Inception Report (20 copies) to the BMA and gave an explanation of the report. The overall work schedule, staffing and plan of operation were explained. The importance of the Study to the current situation and sewerage system development plans were appreciated.

The BMA accepted the Inception Report and agreed to cooperate with the JICA Study Team during the execution of the Study.

## 2 Clarification and Discussion

The contents of the Inception Report were mainly agreed between BMA and JICA Study Team. However, clarification was needed on some matters and some details of the scope of the Study were discussed. The following matters were agreed.

- 2.1 Requests were made for further analyses including pathogens in sludges, total and fecal coliforms, potassium in sludge and nitrogen and phosphorus in sewage and treated effluents. It was agreed that these except potassium which will be implemented by the Study Team would be undertaken by the BMA laboratory and the results included in the Study.
- 2.2 The Study would refer to the conclusions of the Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil Sludge for Bangkok Metropolitan by the Asian Institute of Technology prepared in March 1998.
- 2.3 A list of references was requested for the Inception Report. This list is attached in Appendix 2.
- 2.4 There was concern about the effects of polymers on agricultural land. It was agreed that this would be investigated.
- 2.5 Various options for the transport of sludge were discussed including pumping of liquid sludge. It was agreed that these would be investigated.



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- 2.6 As indicated in the Inception Report, "Appropriate boundary for catchment area for the existing planned schemes shall be established to study the sludge treatment and disposal system".
- 2.7 It was requested that consideration be given to the use of bio-gas from sludge digestion, and sun drying and stabilisation of sludge, and this was agreed to. Sludge destruction by ozonation would also be reported.
- 2.8 It was requested that waste sludge from gas stations be considered in the Study, but it was explained that the Study would focus on the sewage sludge and the night soil which meant the sludge from septic tanks and on-site wastewater treatment plants.
- 2.9 The Study shall consider sludge disposal areas both within the BMA area and in the vicinity as appropriate.
- 2.10 Office Equipment  
On the request of the JICA Study Team, BMA agreed to provide office space as well as the necessary equipment, ie. faximile machine.

### 3 Steering Committee and Counterpart Team

The Steering Committee and Counterpart Team were established and are listed in Appendix 3 and 4.



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Appendix 1

List of Attendants

Thai side

Advisor of Steering Committee

1. Ms. Hansa Songuanoi Assistant Secretary to Bangkok Governor

Steering Committee

Chairman

1. Mr. Nikhom Prachyanakorn Director General of the Department of Drainage and Sewerage, BMA

Vice Chairman

2. Mr. Thongchai Klankrong Deputy Director General of the Department of Drainage and Sewerage, BMA  
Expertise of Sewerage System, BMA  
3. Mr. Piroon Charoenkul Representative of the Department of Public Cleansing, BMA  
5. Ms. Thippawan Paewsakoon Representative of the Department of Policy and Planning, BMA  
6. Mr. Ksemsan Suwarnarat Chulalongkorn University  
Sanitary Engineering Program  
7. Ms. Orawan Siriratpiriya Faculty of Public Health Mahidol University  
8. Mr. Suwit Chumnumsiriwat Environmental Engineering Program  
Faculty of Engineering Kasetsart University  
9. Mr. Chart Chiemchaisri Representative of Office of Environmental Policy and Planning, Ministry of Science Technology and Environment  
10. Miss. Suree Umaralikit Representative of Department of Public Works Ministry of Interior  
11. Mrs. Sonjit Piyasil Representative of Wastewater Management Authority  
12. Mrs. Hatairat Likitanupak Director of Water Quality Management Division, DDS, BMA  
13. Mr. Chanchai Vitoonpanyakit Chief of Technical Sub-Division, Water Quality Management Division  
14. Ms. Apinan Jaruchiyakull

Counterpart

1. Mrs. Suthimol Kessomboon Sanitary Engineer, DDS, BMA  
2. Ms. Ubolwan Boontavee Scientist, DDS, BMA  
3. Ms. Chantana Rirattanapong Scientist, DDS, BMA  
4. Ms. Sermsook Pakkattang Sanitary Scientist, DDS, BMA  
5. Ms. Prayoon Chanya Sanitary Scientist, DDS, BMA

Japanese side

JICA Advisory Committee

1. Mr. Haruki Takahashi Chairman  
2. Mr. Tsuyoshi Yanagi Member



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JICA Head Quarters

1. Mr. Masahito Ueki

Social Development Study Dept, Second  
Development Study Division

JICA Study Team

1. Mr. Keisuke Okazaki
2. Mr. Keith W. Hitchcock
3. Mr. Xavier A. Fernandes
4. Mr. Shigenobu Hibino

Team Leader  
Sewage Treatment Planner  
Sludge Treatment and Disposal / Environment  
Expert  
Coordinator

JICA Expert

1. Mr. Yutaka Iijima

JICA Expert for DDS



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## Appendix 2

### PRELIMINARY LIST OF REFERENCES

The following are considered main references at the outset of the Study. Other references have been collected and will be used as appropriate and further references will be acquired.

- 1 Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil for Bangkok Metropolitan: Final Report, Asian Institute of Technology, March 1998.
- 2 Bangkok Metropolitan Region Wastewater Management Master Plan: PCD, MOSTE, March 1993.
- 3 Implementation plan for sewerage system prepared by BMA as referred to in the Minutes of Meeting on the Scope of Work for this Study, April 1998.



Advisor of Steering Committee

- |   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. Mr. Somjai Nillasithanukros</li> <li>2. Ms. Hansa Songuanoi</li> <li>3. Mr. Sutat Weesakul</li> </ol> | Deputy Bangkok Governor<br>Assistant Secretary to Bangkok Governor<br>Chairman Board Committee of Flood Protection<br>and Management |
|---|--|

Steering Committee

## Chairman

1. Mr. Nikhom Prachyanakorn

Director General of the Department of Drainage  
and Sewerage

## Vice Chairman

2. Mr. Thongchai Klankrong
3. Mr. Piroon Charoenkul
4. Mr. Changthong Opassiriwit

Deputy Director General of the Department  
of Drainage and Sewerage  
Expertise of Sewerage System  
Representative of the Department of Public  
Cleansing

5. Mr. Ksemsan Suwarnarat
6. Ms. Preeda Parkpian
7. Ms. Orawan Siriratpiriya
8. Mr. Suwit Chumnumsiriwat

Representative of the Department of Policy and  
Planning, BMA

9. Mr. Chart Chiemchaisri

Environmental Engineering Program  
Asian Institute of Technology  
Chulalongkorn University

10. Miss. Suree Umaralikit

Sanitary Engineering Program  
Faculty of Public Health Mahidol University  
Environmental Engineering Program  
Faculty of Engineering Kasetsart University

11. Mr. Weera Piriyan

Representative of Office of Environmental  
Policy and Planning, Ministry of Science  
Technology and Environment  
Representative of Department of Agricultural  
Extention, Ministry of Agriculture and  
Co-operatives

12. Mrs. Somjit Piyasil

Representative of Department of Public Works  
Ministry of Interior

13. Mrs. Hatairat Likitanupak

Representative of Wastewater Management  
Authority

14. Mr. Chanchai Vitoonpanyakit

Director of Water Quality Management  
Division, DDS, MBA

15. Ms. Apinan Jaruchaiyakul

Chief of Technical Sub-Division,  
Water Quality Management Division



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THAT COUNTERPART TEAM  
 OF  
 THE STUDY FOR THE MASTER PLAN ON  
 SEWAGE SLUDGE TREATMENT/DISPOSAL AND  
 RECLAIMED WASTEWATER REUSE IN BANGKOK

Appendix 4 List of Counterpart Team

NAME	POSITION	SUB-DIVISION / DIVISION
1. MISS APINAN JARUCHAIYAKUL	SANITARY SCIENTIST      Leader	TECHNICAL / WATER QUALITY MANAGEMENT
2. MRS. SUTHIMOL KESSOMBOON	SANITARY ENGINEER      Sub-Leader	TECHNICAL / WATER QUALITY MANAGEMENT
3. MRS. UBOLWAN BOONTAVEE	SCIENTIST	TECHNICAL / WATER QUALITY MANAGEMENT
4. MRS. CHANTANA RIRATTANAPONG	SCIENTIST	TECHNICAL / WATER QUALITY MANAGEMENT
5. MISS SERMSOOK PAKKATIANG	SANITARY SCIENTIST	TECHNICAL / WATER QUALITY MANAGEMENT
6. MISS PARYOON CHANYA	SANITARY SCIENTIST	WATER QUALITY MANAGEMENT CENTER I / WATER QUALITY MANAGEMENT
7. MISS CHAROENSOOK PUNCHAPONG	SCIENTIST	NIGHT SOIL DISPOSAL / NIGHT SOIL CONTROL / DPC
8. MR. KITCHAPAT YINHIRUN	CIVIL ENGINEER	TECHNICAL / WATER QUALITY MANAGEMENT
9. MR. PRASITH INTHACHOM	CIVIL ENGINEER	SEWER ENGINEER / DRAINAGE SEWER SYSTEM
10. MR. SUWAPHAN CHARMRUNGSRI	CIVIL TECHNICIAN	KLONG MANAGEMENT / KLONG SYSTEM

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*The Study for the Master Plan on Sewage Sludge  
Treatment/Disposal and Reclaimed Reuse in Bangkok*

**Minutes of Technical Meeting No.1**

1. Date: October 19, 1998
2. Time: 1:30 – 2:00 p.m.
2. Place: BMA, Third Floor
3. Attendants:

Counterpart Team

Mr. Chanchai V. Panyakij	Director of Water Quality Management Division, DDS
Miss. Apinan Januchaiyakul	Leder of counterpart team
Mrs. Ubolwan Boontavee	Scientist
Mrs. Chantana Rirattanapong	Scientist
Miss. Sermsook Pakkattang	Sanitary Scientist
Miss. Paryoon Chanya	Sanitary Scientist

Study Team

Mr. K Okazaki	Leader
Mr. K.W. Hitchcock	Sewage Treatment Planner
Mr. X.A. Fernandes	Sludge Treatment and Disposal/ Environment Expert
Mr. T. Naka	Reclaimed Wastewater Reuse Planner
Mr. S. Hibino	Coordinator

4. Contents:

(1) Introduction

Mr. Naka, as the new member of the JICA study team, was introduced to the chairman of the counterpart team. He will examine the effluent reuse aspect for this Study.

(2) Reporting on the current progress of the Study

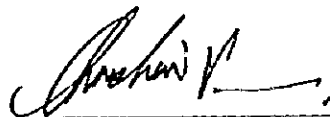
- 1) **Inventory survey of the existing, ongoing and planned project sites**  
Several catchment areas and sites were visited within the BMA areas of Thonburi, Klong Toei and Si Phraya. Closed drainage catchment areas were identified and inspected. A meeting and discussion was held with the contractor (Samsung-Lotte-CEC) for the Yanawa WWTP (Stage 2) scheme.
  - 2) **Selection of Contractor**  
Three local contractors were invited to tender for the monitoring and sampling survey for this Masterplan Study. Following a JICA evaluation, Environment & Laboratory was selected and a contract was signed on 7<sup>th</sup> October 1998.
  - 3) **Determination of sites for field survey**  
The points for sample collection and flow monitoring were selected after visiting the designated two WWTPs and two NSTPs. Sites for the sewage catchment areas were also determined.
  - 4) **Department Public Cleansing (DPC)**  
Contact was made with DPC (Niyom Kannasoot, Mrs. Sainporn) who provided useful data and information on the collection, treatment and disposal of the municipal solid waste.
  - 5) **Asian Institute of Technology (AIT)**  
A meeting with Dr. Preeda Parkpian and Dr. Satoshi Takizawa was held at the AIT and useful guidance, information and data was provided, particularly towards the agricultural disposal sewage sludge.
3. **Confirmation of key issues on implementing the Study**
- (1) **Policy on Nitrogen and Phosphorus removal with sewage treatment**  
Chairman confirmed that the BMA wastewater treatment recommendation for effluent treatment should also include Nitrogen and Phosphorus removal at the proposed WWTPs, although no current BMA research or evidence has pointed towards a 'eutrophication' problem on the river Chao Phraya or the Gulf of Thailand.

(2) Design criteria for intercepting sewer flows

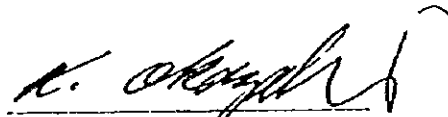
Chairman again confirmed that following extensive discussions at BMA, a factor of 5xDWF is to be applied for the current WWT schemes. However, it is confirmed that it has not been clearly stipulated for the future system and further discussion may be needed before concluding of this criterion.

4. Others

A request by the Study Team was made for ID cards to entry to the various treatment sites and plants under the authority of BMA. This will be provided with a few days following the submission of photographs of all the team members. A letter of authorization to enter BMA premises will also be provided.



Mr. Chanchai V. Panyakij  
Director of Water Quality  
Management Division, DDS



Mr. Keisuke Okazaki  
Team Leader  
Study Team

*The Study for the Master Plan on Sewage Sludge  
Treatment/Disposal and Reclaimed Reuse in Bangkok*

**Minutes of Technical Meeting No.2**

1. **Date:** November 13, 1998
2. **Time:** 1:30 – 2:30 p.m.
2. **Place:** BMA, Third Floor
3. **Attendants:**

Counterpart Team

Mr. Chanchai Vitoonpanyakij	Director of Water Quality Management Division, DDS
Miss. Apinan Jaruchaiyakul	Leader of counterpart team
Mrs. Suthimol Kessomboon	Sub-leader of counterpart team
Mrs. Ubolwan Boontavee	Scientist
Miss. Prayoon Chanya	Sanitary Scientist

Study Team

Mr. K Okazaki	Leader
Mr. K.W. Hitchcock	Sewage Treatment Planner
Mr. X.A. Fernandes	Sludge Treatment and Disposal/ Environment Expert
Mr. T. Naka	Reclaimed Wastewater Reuse Planner
Mr. J. A.L. Chettoe	Organization/Institution Expert
Mr. T. Ishibashi	Economic/Financial Expert
Mr. T. Yamamoto	Facility Designer/Cost Estimator
Mr. S. Hibino	Coordinator

4. **Contents:**

(1) **Introduction**

The new members of the Study Team who arrived in recent days were introduced to the counterpart team. The members are Mr. T. Ishibashi,

Economic/Financial Expert, Mr. J.A.L. Chettoe, Organization/Institution Expert, and Mr. T. Yamamoto, Facility Designer/Cost Estimator. The staff continue first fieldwork period till December 23, 1998.

**(2) Reporting on the current progress and key issues of the Study**

**1) Monthly Progress Report of October**

The Study Team Leader requested the chairman to comment on the Monthly Progress Report submitted on October 22. The chairman replied to comment within one week from now on.

**2) Study for the new developing area for the future sewage system**

The Study Team explained the results of analysis for the sewerage systems in the new areas for development. These areas are located outside the existing and ongoing sewage project area, and the analysis has been carried out based on population projections for the year 2020 and a city development plan prepared by the Department of City Planning, BMA.

The Study Team emphasized the results on the following aspects:

- i) The new sewage developing areas were determined on the basis of population projection, especially attaching importance to high population density area based on the report of Wastewater User Charge.
- ii) The areas have also been selected on the basis of the city development plans including new transportation system, road construction plans and future land use plans.
- iii) The boundary of each catchment area has been determined on the basis of topographic configurations and district boundaries. At the same time, reference was made to the boundaries established in the PCD Master Plan.
- iv) Possible treatment plant sites were selected on the topographic map and subsequent field surveys were carried out to identify potential use of these identified areas.
- v) Consideration was also given to the financial aspects expected in the phasing of implementation for the future.

The Study Team's approach for selection of future sewerage development

were generally accepted by the counterpart team.

- 3) Government and/or BMA policy on development of sewerage system for the BMA area

The chairman announced that the Government has, in general, a decentralization policy for construction of sewerage and wastewater treatment systems. However, there is no clear policy on establishing these future systems either of large schemes as central treatment system or small community systems which would be preferable for the future sewerage system. Therefore, appropriate sizing should be necessary for these future sewerage systems.

- 4) Sludge demand survey

The Study team provided a copy of the final version of the sludge questionnaire to the Chairman of the counterpart team. This included a translated version in Thai. Previous copies were provided to key members of the counterpart team who had provided introduction letters to the provincial officers for the five provincial areas selected by the Study Team for the Sludge Demand Survey. The areas are Nonthaburi, Samut Sakon, Nakhon Pathom, Pathum Thani and Cha-Choeng-Sao. The follow up contact is to be made by week ending 20 Nov. 1998.

- 5) Sampling and monitoring of sludge and wastewater

The Study Team reported that the above survey had completed determinations for the rainy season at the Huay Kwuang and Si Phraya WWTPs as well as the three catchment areas in Klong Toey, Yannawa and Si Phraya. Determinations are presently underway for the dry season. Sampling and monitoring are completed at Si Phraya and Huay Kwuang WWTW, but the three catchment areas are scheduled for sampling on 18-19 Nov. 1998. Results are to be reported two weeks after final site work.

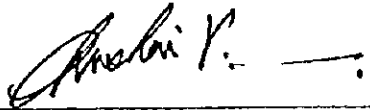
- 6) Reclaimed water reuse survey

Reclaimed water reuse survey have been carrying out by selecting some of the major hotels, building, industries, hospitals, private enterprises and public institutions and organizations. As far as the study results are concerned, it is

envisaged that the reclaimed water reuse in the future is promising and the potential use may increase when the appropriate collection and transportation system have been established.

**(3) Others**

- i) The Study Team requested the counterpart team to provide some existing reports for reference.
- ii) The Study Team informed that the Monthly Progress Report for November will be submitted on 23<sup>rd</sup> of November.
- iii) The Draft Interim Report will be submitted by 18<sup>th</sup> of December. And the meeting for explanation of the Draft Interim Report to the counterpart team will be held 21<sup>st</sup> December before the Study Team's leave on 23<sup>rd</sup>.



Mr. Chanchai Vitoonpanyakij  
Director of Water Quality  
Management Division, DDS



Mr. Keisuke Okazaki  
Team Leader  
Study Team

*The Study for the Master Plan on Sewage Sludge  
Treatment/Disposal and Reclaimed Reuse in Bangkok*

**Minutes of Technical Meeting No.3**

1. **Date:** December 4, 1998
2. **Time:** 1:30 – 2:30 p.m.
2. **Place:** BMA, Third Floor
3. **Attendants:**

Counterpart Team

Mr. Chanchai Vitoonpanyakij	Director of Water Quality Management Division, DDS
Miss. Apinan Jaruchaiyakul	Leader of counterpart team
Mrs. Suthimol Kessomboon	Sub-leader of counterpart team
Mrs. Chantana Rirattanapong	Scientist
Miss. Sermsook Pakkattang	Sanitary Scientist
Miss. Prayoon Chanya	Sanitary Scientist
Mr. Somchai Somvane	Scientist
Mr. Kitchapat Yinhirun	Civil Engineer
Mr. Prasith Inthachom	Civil Engineer
Mr. Kosit Srijaeng	Scientist

Study Team

Mr. K Okazaki	Leader
Mr. K.W. Hitchcock	Sewage Treatment Planner
Mr. X.A. Fernandes	Sludge Treatment and Disposal/ Environment Expert
Mr. T. Naka	Reclaimed Wastewater Reuse Planner
Mr. J. A.L. Chettoe	Organization/Institution Expert
Mr. T. Ishibashi	Economic/Financial Expert
Mr. T. Yamamoto	Facility Designer/Cost Estimator
Mr. S. Hibino	Coordinator



#### **4. Contents:**

The Study Team and the Counterpart Team had a informal technical meeting primarily to discuss the Monthly Progress Report for November on the 2<sup>nd</sup> December, 1998. Items discussed in this meeting are summarized in the Attachment. Following this informal meeting, a formal Technical Meeting No.3 attended by Chairman Mr. Chanchai was held on 4<sup>th</sup> December, 1998. The following is the contents of discussion.

#### **(1) Development Strategy for the New Sewerage System proposed by the Study Team**

##### **1) Nong Bon Scheme**

Nong Bon scheme is previously proposed by BMA to be developed in the near future and stipulated in the Fifth Bangkok Metropolitan Development Plan (1997 – 2001), Department of Policy and Planning. Meanwhile, in accordance with the study results by the Study Team, the Nong Bon scheme is allocated as the third prioritized project defined as the possible sewage development area beyond 2020 due to population projection, land use and city development plans. In this context, the Chairman stated that Study Team's approach on the prioritization on this matter is acceptable and can proceed.

##### **2) Nong Jok Scheme**

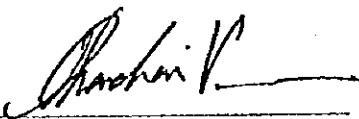
Nong Jok area located in the eastern part of the Study Area is currently proposed as an alternative sewerage system development area by BMA. The Chairman stated that this alternative proposal is merely an idea as a part of the regional development policy of BMA and not the one which may exert on the priority made by the Study Team.

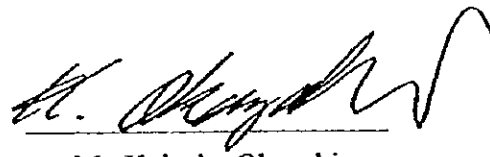
##### **3) Khlong Saen Sep Improvement and proposed Huay Kuwang and Wang Thong Lang Wastewater Schemes**

Improvement program of above canals has been flagged since long time ago. The Chairman stated that the program may be realized in the near future, however it will not such that exert on the strategy of the Master Plan to be prepared by the Study Team.

**(2) Schedules of Submission of Reports and Meeting with Counterpart Team and Steering Committee**

The Study Team reported the schedules attached in the Monthly Progress Report for November regarding submission of the Interim Report and subsequent meetings with the Counterpart Team and Steering Committee members.

  
\_\_\_\_\_  
Mr. Chanchai Vitoonpanyakij  
Director of Water Quality  
Management Division, DDS

  
\_\_\_\_\_  
Mr. Keisuke Okazaki  
Team Leader  
Study Team

## **Attachment**

### **Notes on Technical Meeting of December 2 1998**

The meeting discussed on Sections 2.1, 2.2 and 2.3 of the Monthly Progress Report for November concerning Wastewater Disposal, Sludge Treatment and Disposal and Reclaimed Wastewater Reuse.

#### **(1) Wastewater Disposal**

- 1) The Counterpart Team questioned the base of wastewater flow rate calculation. The Study Team replied that in the Monthly Progress Report, unit flows and loads included in the PCD BMR Wastewater Management Master Plan, 1993 were adopted and applied to the later population forecasts adopted in the Wastewater User Charge Study, 1998. Unit flows and loads are being evaluated and will be adopted in the Interim Report.
- 2) The Counterpart Team questioned the source of 256 l/c/d. The proposed domestic per capita water consumption of 256 l/c/d was as advised by MWA as their planning value for the future projection. This value is also used for current ongoing scheme "Chatuchuk Wastewater Disposal Scheme". The Counterpart Team has further information on this and will provide it to the Study Team.
- 3) The Counterpart Team pointed out that some of the figures described in the report has no reference. The Study Team stated to clarify these figures in the Interim Report.
- 4) The Counterpart Team advised that the Huay Kwang catchment was predominantly medium-poor quality apartment blocks and would therefore have a lower than average water consumption in Bangkok.
- 5) The Counterpart Team questioned the proposed assumption that wastewater production would be 90% of water supply. This view was that water lost would be fully compensated by infiltration into the sewers. The Counterpart Team would provide information from previous studies on this matter to the Study Team.

- 6) The Counterpart Team questioned the average BOD data reported at Huay Kwuang WWTP. This was the reported average for 1997 but the Counterpart Team would provide later more representative data to the Study Team.
- 7) The Counterpart Team asked the source of data of unit loads of 150 mg/l and 200 mg/l. The Study Team explained that all the current ongoing schemes for sewerage system have these conditions in their contract documents. The Counterpart Team will check these documents.
- 8) On page 13, the Water Quality Management Study means the Development of a Framework for Water Quality Management of the Chao Phraya and Thachin Rivers for NEB, MOSTE, 1998. (not 1998)
- 9) The Counterpart Team questioned the source of 0.6-0.8 kg ds/kg BOD. The Study Team replied that this value is generally indicated in the design criteria in world wide.
- 10) Further explanation was needed to the table on page 19. The Study Team advised that this accounted for the forecasted sludge production from current (year 2000) to future (year 2020) on the sludge master plan program to bring the new planned WWTPs into operation.
- 11) The Counterpart Team considered that the forecasts of growth in industrial wastewater were high in Table 2.1.3. The Study Team explained that these were based on the 1993 Master Plan assumed growth rates at the forecast growth in manufacturing GDP. These are being reviewed.
- 12) The Counterpart Team asked for reference on the BMA treated effluent quality standards on page 22.
- 13) The Counterpart Team asked for clarification concerning the suitability of compact WWTP processes on page 23.

**(2) Sludge Treatment and Disposal**

- 1) The Counterpart Team informed that the sludge production at Huay Kwuang

WWTP is about 15% dry solids, not 20%. The Counterpart Team will provide further data.

- 2) Sludge production at Si Phraya WWTP is confirmed at 1 – 2 m<sup>3</sup>/d at 15% dry solids, not 3 m<sup>3</sup>/d.
- 3) The Study Team were asked to provide a reference for the 20 – 25 % dry solids sludge cake produced from sand drying beds.
- 4) A reference was required for the expected 60 g/c/d for sludges from the ex NHA community WWTPs. This is included in the AIT Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil Sludges for BMA, 1998.
- 5) A reference was required for the expected 7.2 t ds/d from the ex NHA community WWTPs. This is also included in the AIT Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil Sludges for BMA, 1998.
- 6) Better distinction was needed between landfill and dumping of solid waste. Nong Khaem and On-nut are only dumping sites.
- 7) On page 30, balance to landfill should read 5400 t/d .
- 8) Details were requested of the preliminary processes required for sludge incineration such as thermal drying, and typical costs addressed later. The process options will be fully described in the Interim Report and costs addressed later.
- 9) The Counterpart Team will provide the pathogen analyses of the sampled sludge cakes next week.

### **(3) Reclaimed Wastewater Reuse**

Non of particular comments were given.

MINUTES OF MEETING  
ON  
INTERIM REPORT

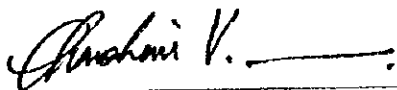
FOR

THE STUDY FOR THE MASTER PLAN  
ON  
SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED  
WASTEWATER REUSE IN BANGKOK  
IN  
THE KINGDOM OF THAILAND

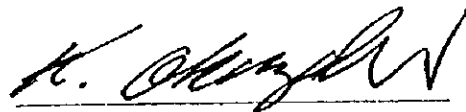
AGREED BETWEEN

THE BANGKOK METROPOLITAN ADMINISTRATION  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM

Bangkok, January 22, 1998

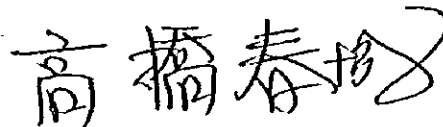


Mr. Chanchai Vitoonpanyakij  
Director  
Division of Water Quality Management  
Department of Drainage and Sewerage  
Bangkok Metropolitan Administration



Mr. Keisuke Okazaki  
Leader of JICA Study Team

Witnessed by



Mr. Haruki Takahashi  
Chairman of Advisory Committee  
of JICA

Upon submission of the Interim Report (20 copies) for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok, a series of meetings were held between the Bangkok Metropolitan Administration (BMA) and the Japan International Cooperation Agency (JICA) Study Team at the BMA Building conference room, Bangkok, Thailand, on 19, 20, 21 January 1999. The list of attendants is given in Appendix 1.

Presentation on the Interim Report was made by the JICA Study Team at the Steering Committee Meeting with participation of Steering Committee Members, the Counterpart, a JICA representative from Tokyo Head Quarters, and JICA Advisory Committee Members. The areas presented included (1) Wastewater Treatment Planning, (2) Sludge Treatment and Disposal Planning, (3) Reclaimed Wastewater Reuse Planning, (4) Financial Analysis and (5) Institutional and Organizational Proposal.

Based on the discussions above, the BMA and the JICA Study Team agreed the followings;

1. Steering Committee Members and the Counterpart raised several comments at the Meeting, among which a significant issue was the reliability of the survey data on wastewater quality and quantity conducted by the Study Team. It was pointed out that this data vary widely and the number of samples was small, so that the results were not reliable enough for use as the design basis for this Master Plan. Furthermore, due to insufficient rainfall the survey ended without sufficient storm event data in both rainy and dry seasons.
2. In view of this constraint, the Thai side requested the Study Team to conduct additional field survey in order to provide sufficient data for study.
3. The Study Team agreed to convey the request to JICA to consider the possibility of extending the field survey based on the understanding that the current number of analyses in the field survey is at a insufficient level due to unexpected weather conditions.
4. If the additional field survey is approved, it was agreed that the Study schedule

would be rearranged as follows;

- a. The Study Team will submit a Progress Report (tentatively named) in late March 1999 by using data collected up to now.
  - b. The Study Team will conduct the additional field survey in dry and rainy seasons in order to obtain more reliable data.
  - c. The Study Team will subsequently submit a Draft Final Report by using the newly collected data from the additional survey.
5. In this case, it was agreed that the Study Team would implement the additional field survey. The Counterpart, in proper guidance of the Study Team, will assist implementation of wastewater sampling and quality tests of BOD, COD and SS for the drainage pipes and WWTPs in dry season, while the Study Team will implement wastewater, sludge and night soil sampling and tests at wastewater treatment plants, night soil treatment plants and drainage pipes in rainy season.
  6. The sludge reuse and disposal plan was not fully described in the Interim Report. The Study Team will develop the outline plan in this two-week fieldwork period in Bangkok, in order to reach a basic agreement with the Counterpart. The Study Team will develop the plan in the Progress Report with newly collected data and information.
  7. The Study Team will re-examine the unit quantity of sewage sludge based on 40 g/c/d BOD and night soil sludge at 40 g/c/d SS used in the Interim Report. This figure will be re-considered and reflected in the Progress Report as a tentatively proposed value. This will be further re-calculated based on data from the additional field survey and will be finally proposed in the Draft Final Report.
  8. Actions for "Comments on the Interim Report from Steering Committee Members and the Counterpart" are described in Appendix 2. Further detailed comments will be scrutinized and reflected in the following Progress Report.
  9. Achievement of each task in the Inception Report was examined and clarified. The Study Team agreed to describe the study results in the Progress Report on those items that left incomplete in the First Field Work period. In addition, implementation for "Minutes of Meeting for the Inception Report" is described in



*Chankrit*  
*AK*



Appendix 3.

10. Thai side requested the Study Team to consider the farmer interview for agricultural use in order to fulfill the scope of work in the Inception Report.

(7/10) *Ranchini V.*  
*AK*

Appendix 1

List of Attendants (1/2)

Thai side

Advisor of Steering Committee

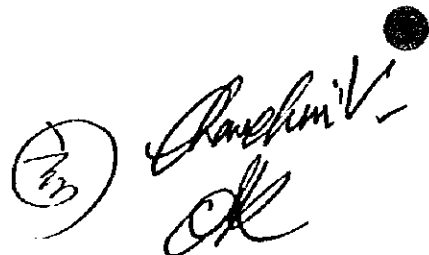
1. Ms. Hansa Sanguanno Assistant Secretary to Bangkok Governor
2. Mr. Sutat Weesakul Chairman Board Committee of Flood Protection and Management

Steering Committee

1. Mr. Thongchai Klankrong Deputy Director General of the Department of Drainage and Sewerage, BMA
2. Mr. Ksemsan Suwarnarat Representative of the Department of Policy and Planning, BMA
3. Ms. Preeda Parkpian Environmental Engineering Program, Asia Institute of Technology
4. Ms. Orawan Siriratpiriya Chulalongkorn University
5. Mr. Suwit Chumnumsiriwat Sanitary Engineering Program, Faculty of Public Health, Mahidol University
6. Mr. Chart Chiemchaisri Environmental Engineering Program, Faculty of Engineering, Kasetsart University
7. Ms. Suree Amaralikit Representative of Office of Environmental Policy and Planning, Ministry of Science Technology and Environment
8. Mr. Pornyot Tienthong Representative of Department of Public Works, Ministry of Interior
9. Mr. Supparat Ittipon Representative of Wastewater Management Authority
10. Mr. Chanchai Vitoonpanyakij Director of Water Quality Management Division, DDS, BMA
11. Ms. Apinan Jaruchaiyakul Chief of Technical Sub-Division, DDS, BMA

Counterpart

1. Ms. Suthimol Kessomboon Sanitary Engineer, DDS, BMA
2. Ms. Ubolwan Boontavee Scientist, DDS, BMA
3. Ms. Chantana Rirattanapong Scientist, DDS, BMA
4. Ms. Sermsook Pakkattang Sanitary Scientist, DDS, BMA
5. Ms. Prayoon Chanya Sanitary Scientist, DDS, BMA
6. Mr. Kitchapat Yinhirum Civil Engineer, DDS, BMA
7. Mr. Prasith Inthachom Civil Engineer, DDS, BMA
8. Mr. Suwapan Chiemrungsi Civil Engineer, DDS, BMA



Appendix 1

List of Attendants (2/2)

Japanese side

JICA Advisory Committee

- |                         |          |
|-------------------------|----------|
| 1. Mr. Haruki Takahashi | Chairman |
| 2. Mr. Tsuyoshi Yanagi  | Member   |

JICA Head Quarters

- |                          |  |
|--------------------------|--|
| 1. Mr. Katsumi Kobayashi | Social Development Study Department, Second Development Study Division |
|--------------------------|--|

JICA Study Team

- |                            |  |
|----------------------------|--|
| 1. Mr. Keisuke Okazaki     | Team Leader  |
| 2. Mr. Keith W. Hitchcock  | Sewage Treatment Planner                           |
| 3. Mr. Xavier A. Fernandes | Sludge Treatment and Disposal / Environment Expert |
| 4. Mr. Toshiki Naka        | Reclaimed Wastewater Reuse Planner                 |
| 5. Mr. Toru Ishibashi      | Economic / Financial Expert                        |
| 6. Mr. Shigenobu Hibino    | Coordinator  |

JICA Expert

- |                      |                          |
|----------------------|--------------------------|
| 1. Mr. Yutaka Iijima | JICA Expert for DDS, BMA |
|----------------------|--------------------------|

(7/3)

*Shimizu*  
*OK*

**Actions to the Comments on the Interim Report (1/3)**

Comment Source	Comments	Action by the Study Team
Steering Committee	1) The unit domestic BOD load of 40 g/c/d is judged to be too high, especially in the light of the Si Phraya wastewater influent quality.	This is to be re-considered and tentatively proposed value will be presented by the Study Team during the First Field Work. This will be described in the Progress Report (tentative name). A final proposal will be made after the implementation of additional Field Survey and presented in the Draft Final Report.
	2) The wastewater for domestic, commercial and institutional, and industrial flows and loads should be proposed by showing their ranges of applicable quantity.	This will be included in the Progress Report (tentative name).
	3) The main strategy proposals were asked to be included in the Executive Summary.	It will be given in the Progress Report (tentative name).
	4) More information was required on proposals for sludge treatment, and it was requested to consider methods of sludge minimization.	Descriptions will be given in the Progress Report (tentative name).
	5) There was concern that the sludge demand survey was addressed to the Kaset Tamboons rather to the farmers themselves.	The Study Team will make a recommendation for further questionnaire survey directed to the farmers. These will be included in the Progress Report (tentative name).

*(Signature)*  
*(Signature)*

Appendix 2

Actions to the Comments on the Interim Report (2/3)

Comment Source	Comments	Action by the Study Team
Steering Committee (continue)	6) The need for a marketing to determine the sludge demand was pointed out.	It will be described in the Progress Report (tentative name). The sludge demand will be evaluated from the total potential and the actual available capacity for the disposal options.
	7) Description for the sludge treatment process is needed.	It will be described in the Progress Report (tentative name).
	8) Co-composting plan in combination of solid waste and sewage and night soil sludge was requested to establish.	The plan will be studied on the basis of literatures adopted worldwide and will be described in the Progress Report (tentative name).
	9) There is a need to develop new standards for treated effluents for various re-uses. A particular request was made for standards for irrigation of different type of tropical crops and potting materials.	It will be described in the Progress Report (tentative name) as a reference.
	10) In reclaimed wastewater reuse plan, removal of color and salt is a significant matter to consider.	It will be studied and described in the Progress Report (tentative name).

(3)

*Chauhan*  
*DL*

Appendix 2

Actions to the Comments on the Interim Report (3/3)

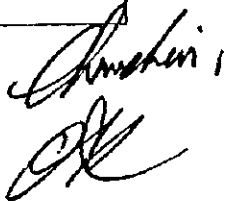
Comment Source	Comments	Action by the Study Team
Counterpart	<ol style="list-style-type: none"> <li>1) Night soil contained TS 4% and subsequent dry solid content of 40 g/c/d is too high.</li> <li>2) Field Survey Data regarding wastewater quality and quantity show much different value than previously obtained data by DDS.</li> </ol>	<p>This issue will be adjusted as stated previously.</p> <p>Calculation errors will be corrected in the Progress Report (tentative name). The difference in the data from the previous survey by DDS in quality shall be explained in the Progress Report (tentative name) and will be evaluated in comparison with the additional survey results to be undertaken as stated previously.</p>
3)	Sludge disposal amount and methods should be stated.	This will be done as mentioned previously.

Handwritten signature and initials, possibly 'Chanchai V.' and 'AK'.

Appendix 3

Actions to the Additional Comments in the Inception Report (1/2)

Comment Source	Comments	Action by the Study Team
Inception Report	<p>(Number of heading is referred to the Minutes of Meeting for Inception Report)</p> <p>2.1 Requests were made for further analyses including pathogens in sludges, total and fecal coliforms, potassium in sludge and nitrogen and phosphorus in sewage and treated effluents. It was agreed that these except potassium which will be implemented by the Study Team would be undertaken by the BMA laboratory and the results included in the Study.</p>	All the tests have been completed. Consideration to these tests will be given in the Progress Report (tentative name).
	<p>2.2 The Study would refer to the conclusions of the Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil Sludge for Bangkok Metropolitan by the Asian Institute of Technology prepared in March 1998.</p>	The Study Team reviewed the Feasibility Report and utilized to a maximum extent for the preparation of the Interim Report.
	<p>2.3 A list of references was requested for the Inception Report. This list is attached in Appendix 2 to the Inception Report.</p>	All the references listed in Appendix in the Inception Report were referred to the Interim Report.
	<p>2.4 There was concern about the effects of polymers on agricultural land. It was agreed that this would be investigated.</p>	The effects of polymers used for sludge treatment on agricultural land were investigated and it was explained to the Counterpart Team. It was not described in the Interim Report, but will be stated in the Progress Report (tentative name).

(3/3)  


**Actions to the Additional Comments in the Inception Report (2/2)**

Comment Source	Comments	Action by the Study Team
Inception Report (continue)	2.5 Various options for the transport of sludge were discussed including pumping of liquid sludge. It was agreed that these would be investigated.	These were investigated and further details will be given in the Progress Report (tentative name).
	2.6 As indicated in the Inception Report, "Appropriate boundary for catchment area for the existing planned schemes shall be established to study the sludge treatment and disposal system".	This was established and described in the Interim Report.
	2.7 It was requested that consideration be given to the use of bio-gas from sludge digestion, and sun drying and stabilisation of sludge, and this was agreed to Sludge destruction by ozonation would also be reported.	A comparison study was made, but not described in the Interim Report. It will be described in the Progress Report (tentative name).
	2.9 The Study shall consider sludge disposal areas both within the BMA area and in the vicinity as appropriate.	It was not described in the Interim Report, but will be described in the Progress Report (tentative name). During the additional field survey period, supplementary data will be collected and Study Teams final presentation will be given in the Draft Final Report.

Handwritten signatures and initials, including a large signature that appears to be 'Ramesh' and other initials.



*The Study for the Master Plan on Sewage Sludge  
Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok*

**Minutes of Meeting**

1. Date: February 10 and 11, 1999
2. Time: 1.00 p.m. on 10 February 10, 1999  
9.30 a.m. on 11 February 11, 1999
3. Place: BMA, Sixth Floor
4. Attendants:

Counterpart Team

Miss. Apinan Jaruchaiyakul	Leader of counterpart team
Mrs. Suthimol Kessomboon	Sub-leader of counterpart team
Mrs. Ubolwan Boontavee	Scientist
Mrs. Chantana Rirattanapong	Scientist
Miss. Sermsook Pakkattang	Sanitary Scientist
Mr. Kitchapat Yinhirun	Civil Engineer

Study Team

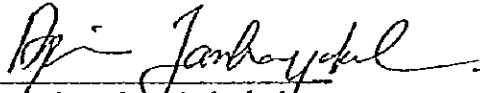
Mr. K. Okazaki	Leader
Mr. K. W. Hitchcock	Sewage Treatment Planner
Mr. X. A. Fernandes	Sludge Treatment and Disposal/ Environment Expert
Mr. T. Naka	Reclaimed Wastewater Reuse Planner
Mr. T. Ishibashi	Economic/Financial Expert
Mr. T. Shoji	Advisor

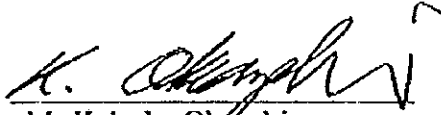
5. Contents:

The main purpose of the meetings was to present the issues identified and commented by the Steering Committee Meeting on 19 January 1999, and the various issues attached to the minutes of this meeting. The counterpart team understand the issues presented by the Study Team which described hereinafter.

- 1) For the purposes of the March Progress Report it was proposed by the Study Team to assume that the domestic unit BOD load in wastewater of 40 g/c/d as proposed in the Interim Report is appropriate at the inlet to the drain, but that a BOD Reduction Factor of 30% would be applied to allow BOD losses in the drainage system by assuming. These figures will be revised after further survey data by the Study Team becomes available. For it would not appropriate to determine the parameter only by the less number of survey results at Si Phraya, Huay Kwuang WWTPs and limited number of data on drainage pipes.
- 2) The Study Team proposed to increase the sludge generation rate from 0.7 kg ds/kg BOD to 1.0 kg ds/kg BOD for the purposes of the Master Plan because of lime treatment.
- 3) The Study Team proposed to reduce the night soil total solids from 40 g/c/d to 18 g/c/d on the basis of a recent AIT survey. This would be used as the basis of night soil sludge solids.
- 4) The proportion of night soil to be collected rising to 20% in 2020 was explained by the Study Team. This would be used as the basis of night soil sludge generation.
- 5) The on site sludge treatment process and central sludge treatment process for sludge treatment were discussed and the Study Team will make comparison the advantage and disadvantage between two options.

- 6) The analysis for developing the sludge treatment and disposal strategy was explained.
- 7) The results of the sludge demand and marketing surveys were presented indicating that the potential for agricultural use would exceed sludge production. This has been further scrutinized forecasting heavy metal content in each catchment area based on the industrial record in each district.
- 8) The proposals for treated wastewater re-use were explained including further analysis on the wastewater reuse standards and drought mitigation.
- 9) The sludge treatment and disposal plan was presented indicating sources of sludge, regional sludge treatment centers and disposal types and locations.
- 10) Further discussion took place concerning heavy metals in the sludges and the Study Team were asked to make a further study by evaluating chemical analysis from the past records.

  
Miss Apinan Jarachaiyakul  
Counterpart Team  
Leader, Water Quality  
Management Division, DDS

  
Mr. Keisuke Okazaki  
Team Leader  
Study Team

*The Study for the Master Plan on Sewage Sludge  
Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok*

**Minutes of Steering Committee Meeting (No.1)  
for Second Field Work**

1. Date: June 22, 1998
2. Time: 9:00 – 12:00 a.m.
3. Place: BMA, Conference Room
4. Attendants:

Steering Committee Member

Dr. Ksemsan Suwarnarat

Mr. Thongchai Klankrong

Mr. Rungsan Tongnguan

Mr. Pornyot Teantong

Ms. Suree Amaralikit

Mr. Udomsak Kongmueng

Ms. Hatairat Likitanupark

Ms. Orawan Sirirapiriya

Mr. Chart Chiemchaisri

Mr. Anuchit Charoensrisomchit

Mr. Chanchai Vitoonpanyakij

Miss. Apinan Jaruchaiyakul

Counterpart Team

Miss. Apinan Jaruchaiyakul

Mrs. Suthimol Kessomboon

Ms. Chantana Rirattanapong

Representative of the Department  
of Policy and Planning of BMA

General Director of the  
Department of Drainage and  
Sewerage

Representative of Department of  
Agricultural and Co-operation

Representative of Department of  
Public Works, Ministry of Interior

Representative of Office of  
Environment Policy and Planning,  
Ministry of Science Technology  
and Environment

Representative of Sanitary  
Engineering Program Faculty of  
Public Health,  
Mahidol University

Representative of Wastewater  
Management Authority

The Institute of Environmental  
Research, Chulalongkorn  
University

Environmental Engineering  
Program, Faculty of Engineering,  
Kasetsart University

Representative of the Department  
of Public Cleansing

Director of Water Quality  
Management Division, DDS

Chief of Technical Subdivision,  
DDS

Leader of counterpart team

Sub-leader of counterpart team

Scientist, DDS, BMA

Ms. Prayoon Chanya  
Ms. Sermsook Pakkattang  
Mr. Kitchapat Yinhirun

Sanitary Scientist, DDS, BMA  
Sanitary Scientist, DDS, BMA  
Civil Engineer

Study Team

Mr. K Okazaki  
Mr. K.W. Hitchcock  
Mr. T. Shoji

Leader  
Sewage Treatment Planner  
Sludge Treatment and Disposal/  
Environment Expert

#### 4. Contents:

Dr. Kasemsan, Chairman of the meeting opened the meeting and introduced the agenda. The major items described and discussed in the meeting are as follows.

- (1) The Study Team explained the progress of the First Year Study. The Study Team also explained the schedule, program and major tasks to be carried out in the Second Year Study. Of the Second Year Study, the Second Field Work from June 6<sup>th</sup> to August 6<sup>th</sup> includes wastewater quality and sludge investigation survey as an additional survey as agreed with JICA. This survey may result in changes to the parameters affecting sludge production and the proportion of the sludge contaminated with heavy metals.

The Draft Final Report issued in March was to be regarded as a Progress Report and the Draft Final Report (Revised Edition) will be issued in August following the Second Home Work in Japan. However, the Study Team proposed to prepare Technical Notes on the key changes to the proposals included in the previous Draft Final Report before departing to Japan in early August.

- (2) The Study Team presented the proposals for sludge treatment and disposal described in the Draft Final Report and submitted an additional technical notes which included the approach to developing these proposals in the Second Year Study. In particular, these included further consideration of treatment and disposal of heavy metal contaminated sludges and incineration, full use of the Nong Khaem Sludge Treatment Center (STC) of which details were only recently available, composting process and plant locations, and sludge transport arrangements.
- (3) A Steering Committee Member asked the reason for presenting the maximum values of the heavy metal analyses. It was explained by the Study Team that these demonstrated the extent of the risks associated with the heavy metals.

The Steering Committee Member asked that alternative disposal methods be recommended corresponding to the risks associated with the heavy metals. The Steering Committee Member also asked that recommendations be given for routine monitoring of heavy metals in sludges and for the methods of analysis. The Study Team agreed to describe all those recommendation in the Draft Final Report (Revised Edition).

- (4) A Steering Committee Member was concerned about the location of composting plants especially regarding odour during transport, the transport distance, local objections to building such plants, and management arrangements. The Study Team will consider this comment in the formulation work of the Draft Final Report (Revised Edition).
- (5) A Steering Committee Member suggested co-composting with municipal solid waste and explained that the ON-Nut co-composting plant was being re-commissioned. The member also indicated the demand for "humus" from city wastes which was acknowledged in a recent seminar on agricultural soils and asked for low technology for "green" sustainable options in the Master Plan. The Study Team replied that the engineers of the Team had investigated co-composting. From the information obtained, it was neither favored by the purchasers nor profitable. Further, classification of solid waste is difficult under the current collection system in Bangkok. Therefore, the Study Team considered this a low priority option in this Master Plan. In order to establish this system, it would be important to improve management coordination between DDS and DPC. The Study Team will further investigate the possibility of establishing this system.
- (6) A Steering Committee Member pointed out the mistake in the titles of Tables 4.4.2.3 and 4.4.2.4 in Volume II of the March Report where "WWTP" should read "NSTP".
- (7) A Steering Committee Member asked that the method of analysis for heavy metals be quoted in the Report. He pointed out the need to establish heavy metal toleration limits which related to the specific local conditions concerning soils and crops and the need to develop specific standards for Thailand. He asked that the general background for establishing current standards of sludge reuse for agricultural purpose in Japan, USA and European countries be described. The Study Team agreed to describe the general methods adopted in advanced countries.
- (8) A Steering Committee Member asked the Study Team to consider sludge pumping, pathogen removal in composting and thermophylic digestion.


It was explained by the Study Team that sludge transport options will be studied further and that cost would be the key factor although the traffic problems of trucking sludge cake would be acknowledged. The Master Plan would consider all suitable options and finalize in the Draft Final Report (Revised Edition). The Study Team would consider pathogen removal in all the treatment options proposed.

- (9) A Steering Committee Member questioned the capacity of the new Nong Khaem STC in relation to the need of the Master Plan. The capacity would be taken into account in the Master Plan in relation to the estimation of high risk of heavy metal sludges and treatment. On the basis of the data recently obtained, this will be investigated and described in the Draft Final Report (Revised Edition).

- (10) The Study Team described the development of the conceptual plans for future wastewater services from the proposals included in the Draft Final Report in March. In particular, the Study Team described the BOD Reduction Factor to account for losses in wastewater BOD in the drainage systems and the outline arrangements for interceptor sewers and wastewater treatment in the proposed nine new wastewater schemes.
- (11) A Steering Committee Member asked whether BOD reduction due to biological de-composition in the drainage system could be accounted for in terms of length of the sewers between the source and the treatment plant.

The Study Team replied that difficulties of this but would propose investigations for a future study. The further wastewater quality data from the second survey will be used in re-evaluating the proposed BOD Reduction Factor.

- (12) A Steering Committee Member expressed the importance of compactness and operational efficiency in WWTP process selection.



Mr. Chanchai Vitoonpanyakij  
Director of Water Quality  
Management Division, DDS



Mr. Keisuke Okazaki  
Team Leader  
JICA Study Team

MINUTES OF MEETING  
ON  
DRAFT FINAL REPORT (REVISED EDITION)

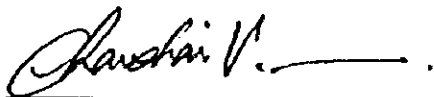
FOR

THE STUDY FOR THE MASTER PLAN  
ON  
SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED  
WASTEWATER REUSE IN BANGKOK  
IN  
THE KINGDOM OF THAILAND

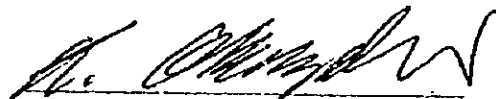
AGREED BETWEEN

THE BANGKOK METROPOLITAN ADMINISTRATION  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM

Bangkok, September 9, 1999

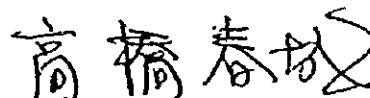


Mr. Chanchai Vitoonpanyakij  
Director  
Division of Water Quality Management  
Department of Drainage and Sewerage  
Bangkok Metropolitan Administration



Mr. Keisuke Okazaki  
Leader of JICA Study Team

Witnessed by



Mr. Haruki Takahashi  
Chairman of Advisory Committee  
of JICA



Upon submission of the Draft Final Report (Revised Edition) (20 copies) for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok, a series of meetings were held between the Bangkok Metropolitan Administration (BMA) and the Japan International Cooperation Agency (JICA) Study Team at the BMA Building conference room, Bangkok, Thailand, on 3, 6, and 7 September 1999. The list of attendants is given in Appendix 1.

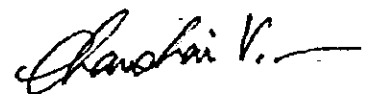
Presentation of the Draft Final Report (Revised Edition) was made by the JICA Study Team at the Steering Committee Meeting with participation of Steering Committee Members, the Counterpart Team and JICA Advisory Committee Members. The areas presented included (1) Wastewater Treatment Planning, (2) Sludge Treatment and Disposal Planning including Compost Demand and Marketing Survey and (3) Financial Analysis.

Based on the above, the BMA and the JICA Study Team discussed and agreed the following:

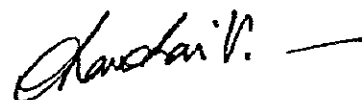
- 1 The Study Team was asked to indicate the wastewater scheme areas in which the heavy metals were discharged. It was explained that there were only four available sources of sludge cake for analysis and it was not possible to establish which of the future scheme areas would produce heavy metal contaminated sludge. Consequently, the Study Team decided to carry out risk study for the entire sewage scheme areas. The risk assessment procedure adopted was based on the number and locations of industries and factories likely to produce toxic wastewater and, therefore it provides an indication of the relative likelihood of toxic heavy metal contamination. The Study Team recommended BMA to conduct more investigation on sludge characteristics before implementation of sludge utilisation.
- 2 The Study Team was requested to add explanation in the text that the data reported in the Table 4.3.1 is only probability of heavy metals in existing sludge.
- 3 The Study Team was requested to show analysis methods of heavy metal of Japanese Standard in the report to enable understanding the difference from AWWA that commonly used in Thailand.

  
K-41





- 4 Some additional notes on Table 7.1.1 was requested to give full explanation on column (H) and (K) for easy understanding.
- 5 The Study Team was asked to indicate the possible ranges of estimated sludge treatment/disposal amount for each treatment option proposed. The Study Team explained that, by using the above mentioned approach to forecast the heavy metal contamination risk assessment, sludge from 8 WWTPs showing the highest probability of toxic heavy metal contamination were assessed as High Risk. The Study Team suggested that it was first necessary to establish standards for toxic limits on sludge for disposal to agricultural land and also for landfill. Sludge could then be assessed in comparison with the standards at the implementation stage.
- 6 The Steering Committee asked if sludge is used only in neighbouring provinces, since the proposed locations of compost factories by the Study Team are in East, North and West regions. The Study Team explained that, since compost plant locations were preliminarily proposed in agricultural areas, the compost would be certainly used in Bangkok and these locations will need further investigation. Therefore, it was agreed that specific locations of compost factories should not be clearly mentioned in the report, and Nong Khaem would be suggested as one of the possible candidates of West composting plant.



Appendix 1

List of Attendants (2/2)

Japanese side

JICA Advisory Committee

- |                         |          |
|-------------------------|----------|
| 1. Mr. Haruki Takahashi | Chairman |
| 2. Mr. Tsuyoshi Yanagi  | Member   |

JICA Study Team

- |                           |                                      |
|---------------------------|--------------------------------------|
| 1. Mr. Keisuke Okazaki    | Team Leader                          |
| 2. Mr. Keith W. Hitchcock | Sewage Treatment Planner             |
| 3. Mr. Tadashi Shoji      | Sludge Treatment and Disposal Expert |
| 4. Mr. Toru Ishibashi     | Economic / Financial Expert          |

JICA Expert

- |                      |                          |
|----------------------|--------------------------|
| 1. Mr. Yutaka Iijima | JICA Expert for DDS, BMA |
|----------------------|--------------------------|



**L. STANDARDS & PRINCIPLES, ETC., FOR THE APPLICATION OF  
WASTEWATER SLUDGE TO AGRICULTURAL LAND IN THE  
PREFECTURES**

**L. STANDARDS & PRINCIPLES, ETC., FOR THE APPLICATION OF  
WASTEWATER SLUDGE TO AGRICULTURAL LAND  
IN THE PREFECTURES**

(Quoted from the "Survey on appropriate management of the use of wastewater sludge on agricultural land, etc." conducted by the Japan Sewage Works Agency of the Sewerage & Sewage Purification Department, City Bureau, Ministry of Construction in March 1994.)

**1. Hokkaido Prefecture**

Standards for the application of urban wastewater sludge on agricultural land (1989, partially amended)

- (1) Sludge applied to agricultural land shall be notified as a special fertilizer as stipulated under the Fertilizer Control Act, and shall be in a solid form (water content less than about 80%).
- (2) In principle, the direct application of raw sludge to agricultural land should be avoided, and it should instead be composted or mixed with organic substances to form a compound compost. In particular, dewatered sludge that has not undergone digestion or fermentation treatment shall not be applied to agricultural land on which food crops are cultivated that are normally eaten raw.
- (3) The amount of sludge applied (dry equivalent/per year/per 10 are (1,000 m<sup>2</sup>)) shall be limited to 1 ton for limed sludge and 0.5 tons for polymer dosed digested sludge. Moreover, the amount to be applied shall be adjusted to take account of the fertiliser value which varies according to the type of sludge and the degree of decomposition.
- (4) The surface soil after the application of sludge shall satisfy the following criteria.
  - 1) Limed sludge: the pH in groundwater shall be no more than 6.5 and the base saturation no more than 80%.
  - 2) Polymer dosed digested sludge: the pH in groundwater shall be between 6.0 and 6.5.
  - 3) Zinc content (determined by the strong acid decomposition method) shall not exceed 120 ppm.

References: "The Chemical Properties of Wastewater Sludge and its Use on Agricultural Land" (1982)

“Methods of Agricultural Use of Limed Wastewater Sludge Compost” (1986)

“Application of Polymer Dosed Digested Wastewater Sludge to Crop Fields and Simple Monitoring Methods” (1988)

## 2. Tokyo Prefecture

The Agriculture, Forestry and Fisheries Department of the Tokyo Metropolitan Government's Labour Economy Bureau has stipulated the following guidelines for the application to agricultural land of composted dewatered cake (named lime-treated sludge fertilizer) formed by adding ferric chloride and calcium hydroxide after thickening raw sludge produced by the Minami Tama Waste Treatment Plant.

### (1) Properties and Composition

- 1) The lime content is considerably greater than in other organic substances, and has capacity to neutralize acid soil. On the other hand, the organic content is small and its soil improvement function as an organic substance is therefore limited.

The content of hazardous elements such as heavy metals is below the regulation value for arsenic, cadmium, and mercury (for which regulation values exist for special fertilizers), and at a low concentration for other elements.

- 2) Since it has less than half the alkali concentration of lime-based materials in common use (calcium carbide, molten phosphate, magnesia lime, etc.), similar acidity improvement effects can be achieved by using about twice the amount of these lime-based materials.
- 3) As an organic material, the fertilizer effect of nitrogen is relatively high, corresponding to about 60% utilization of elemental nitrogen in chemical fertilizer.

Typical composition of the main properties (without drying) is as follows:

Total nitrogen (N)	1.5-2%	Organic matter	20-30%
Total phosphorus (P <sub>2</sub> O <sub>5</sub> )	2-3%	pH	7-8
Alkali content	16-18%	Water content	30-35%

### (2) Application Volumes and Frequencies

The appropriate volume for application depends on the acidity of the soil and the type of crop, but a guide is given as below. For vegetables and other field crops

the application should be twice a year, and for other crops once a year. No application should be made to alkali soils.

#### Guide to application volumes

Crop	Low acidity soil	High acidity soil
Vegetables	0.5-1 tons/crop	1-1.5 tons/crop
Ordinary field crops	0.4-0.6 "	0.5-1 "
Fruit trees	1-1.5 tons/year	1.5-2 tons/year
Shrubs & trees	0.5-1 "	1-1.5 "
Mulberry trees	1-1.5 "	1.5-2 "
Grass	0.5-1 "	1-1.5 "

#### (3) Caution when applying

- 1) When applying, chemical fertilizer corresponding to the standard amount for fertilizer per crop stipulated by the Tokyo Metropolitan Government should be added.
- 2) Subsequent application of three-element fertilizer should be carried out in accordance with the state of growth.

(Currently, production of fertilizer at the Minami Tama Waste Treatment Plant has been discontinued.)

### 3. Saga Prefecture

The following guiding principles concerning the application of wastewater sludge fertilizer established by the Agricultural Produce Division Section of Saga Prefecture's Agriculture and Forestry Department.

#### (1) Standards for application of wastewater sludge fertilizer

- 1) Raw sludge (i.e. sludge prior to treatment and registration as sludge fertilizer) should not be applied, since quality control and testing for hazardous properties is inadequate.
- 2) When applying sludge fertilizer properly registered as special fertilizer, care should be taken not to apply excessive quantities as this may cause the soil to become alkali, contaminated with heavy metals etc. Similarly, due care should be taken of the accumulated amounts of fertilizer applied over the years, to avoid pollution of the soil environment. Standards for application for land type and crop are as follows.

Land Type	Target Crop	Amount of Unprocessed Fertilizer (water content 60%) applied per year per 10 ares (1,000 m <sup>2</sup> )	Notes for Application
Wet Fields (mature)	Rice, Barley, Soybeans, etc.	200 - 400 kg	Apply before planting and mix well with planting soil. Do not apply to soil with a pH in groundwater of 6 or more.
	Greenhouse Grown Vegetables	400 - 600 kg	Apply before planting and mix well. Do not apply to soil with a pH in groundwater of 6 or more.
(immature)	Rice, Barley, Soybeans, etc.	1 - 2 t	Apply for 3 years after preparation of cut-earth fields, fields with mountain topsoil, etc. Thereafter, apply as per mature fields.
Dry fields (mature)	Ordinary crops	400 - 600 kg	Mix well in 15cm of planting soil. Do not apply to soil with a pH in groundwater of 6 or more.
	Greenhouse Crops	400 - 600 kg	Apply before planting, mix well. Do not apply to soil with a pH in groundwater of 6 or more.
	Flowering Shrubs & Trees	600 - 800 kg	Mix well in planting soil. Do not apply to soil with a pH in groundwater of 6 or more.
(immature)	Ordinary Crops	2 - 4 t	Apply for 3 years after preparation of cut-earth fields, fields with mountain topsoil, etc. Thereafter, apply as per mature fields.
Orchards (mature)	Fruit trees	400 - 600 kg	Do not apply in locations with a soil pH in groundwater of 5.5 or more for satsuma oranges and 6 or more for grapes.
	Mulberry Trees	400 - 1,000 kg	Mix well to a depth of 20-30cm. Do not apply to soil with a pH in groundwater of 5.5 or more. Avoid continuous use.
	Tea	200 - 400 kg	Do not apply to soil with a pH in groundwater of 5 or more. Avoid continuous use.
(immature)	Fruit trees, Mulberry Trees, etc.	2 - 4 t	Apply for 3 years after formation of orchard land using cut earth, mountain topsoil, etc. Thereafter, apply as per mature orchards.
Seedling Planting Soil	-	5-10% of the Planting Soil	Apply one month before sowing (planting) and mix well with the planting soil.

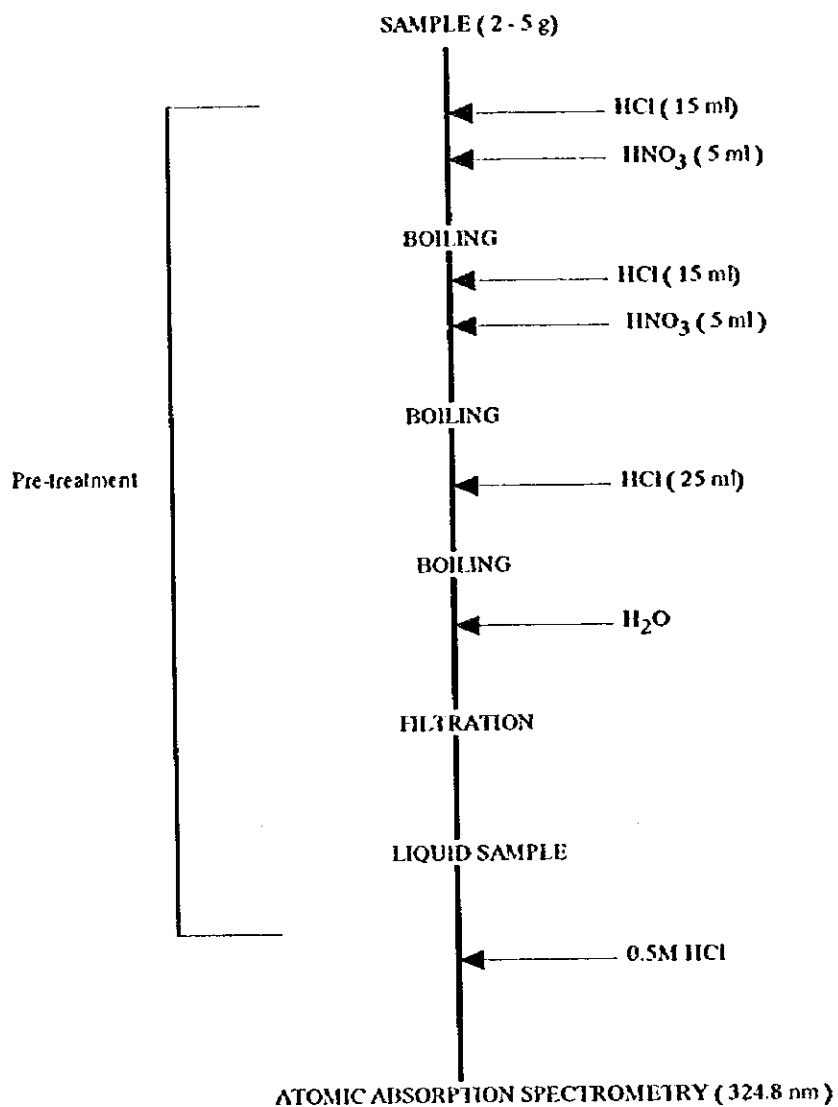


**M. SCHEMATIC FLOW OF MEASUREMENT AND ANALYSIS PROCEDURE  
FOR HEAVY METAL CONTENTS IN FERTILIZER IN JAPAN**

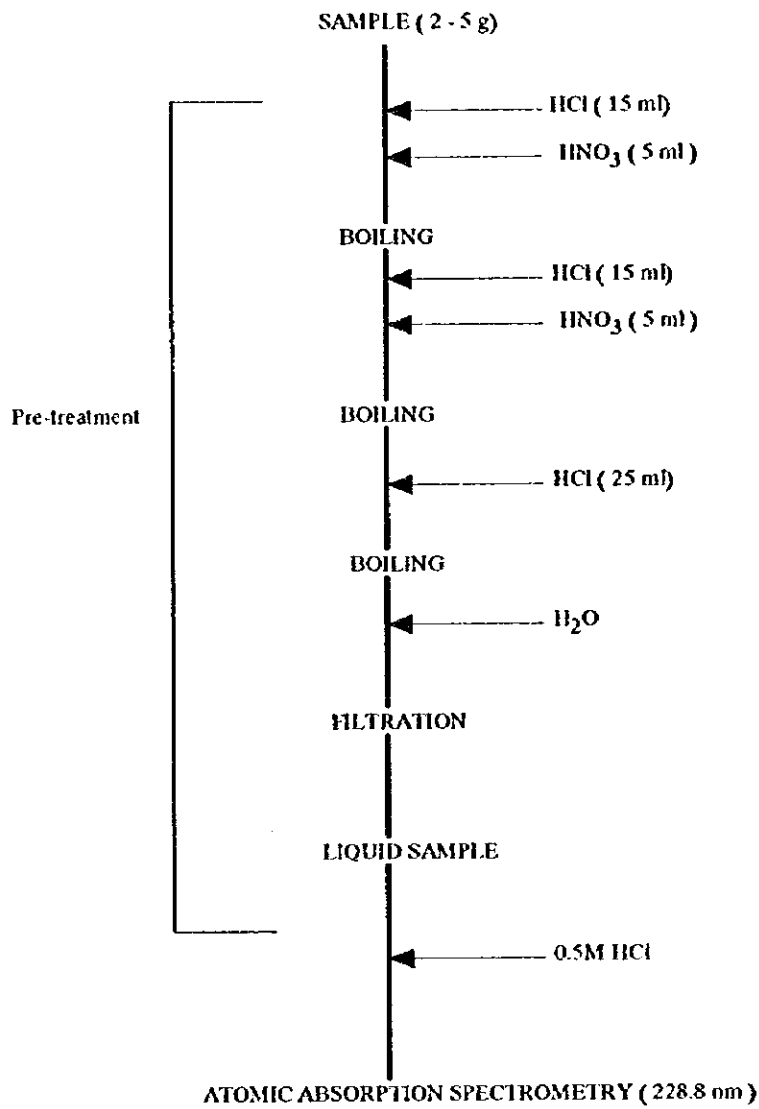


M. SCHEMATIC FLOW OF MEASUREMENT AND ANALYSIS  
PROCEDURE FOR HEAVY METAL CONTENTS IN FERTILIZER IN  
JAPAN

Schematic flow of the measurement and analysis procedure for heavy metal contents in sludge, which are used in Japan, are presented herewith for reference. These methods are specified in the "Authorized Fertilizer Analysis Method" established by the National Institute of Agro-Environmental Sciences in the Ministry of Agriculture, Forestry and Fisheries of Japan.



Note: The figure illustrates the procedure of the Atomic absorption spectrometry method specified in the "Authorized Fertilizer Analysis Method".



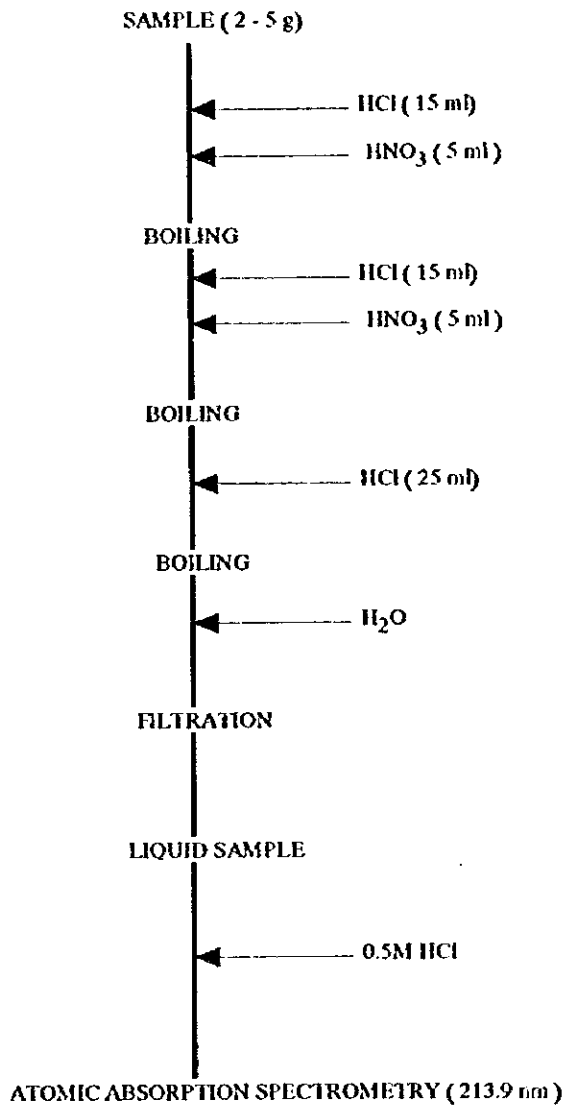
Note: The figure illustrates the procedure of the Atomic absorption spectrometry method specified in the "Authorized Fertilizer Analysis Method".

THE STUDY FOR MASTER PLAN ON  
SEWAGE SLUDGE TREATMENT / DISPOSAL AND  
RECLAIMED WASTEWATER REUSE IN BANGKOK

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure M.2  
SCHEMATIC FLOW OF MEASUREMENT AND  
ANALYSIS PROCEDURE FOR CADMIUM (Cd)

Pre-treatment

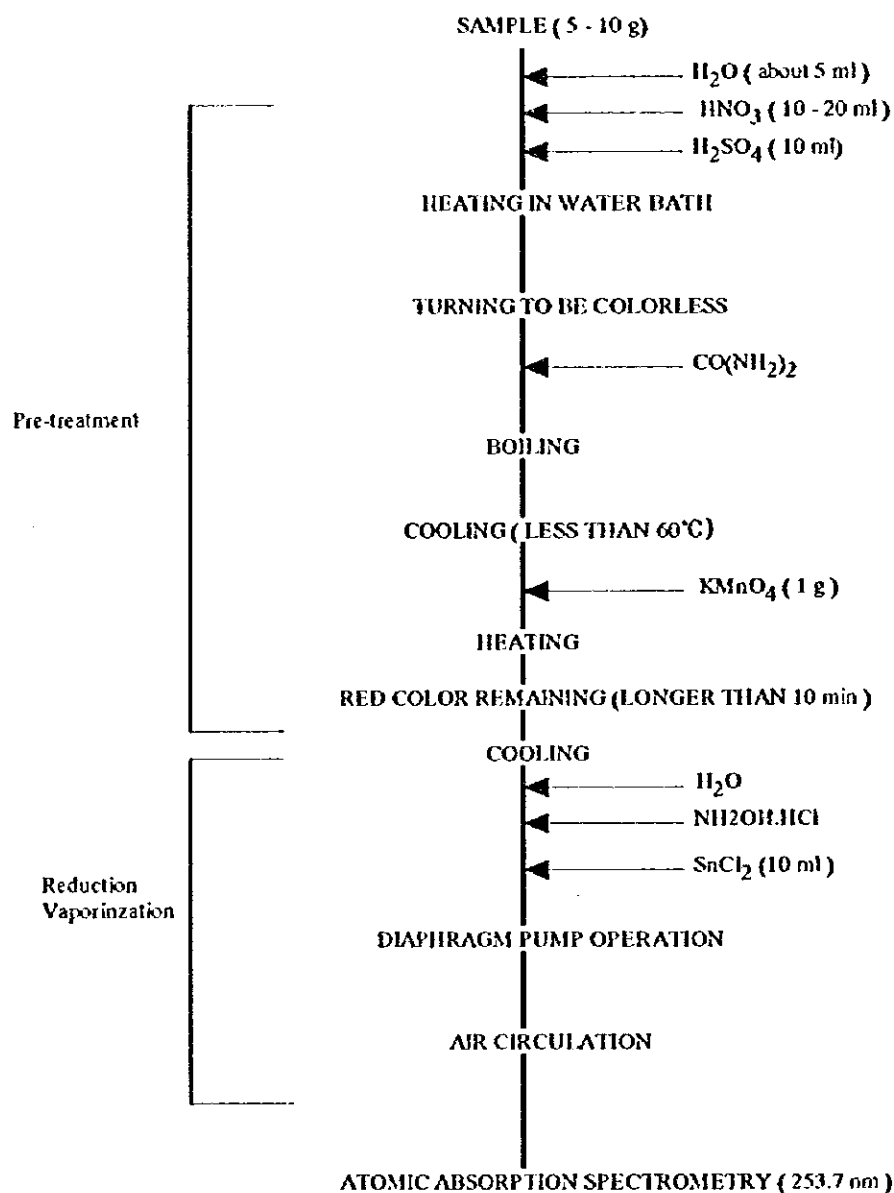


Note: The figure illustrates the procedure of the Atomic absorption spectrometry method specified in the "Authorized Fertilizer Analysis Method".

THE STUDY FOR MASTER PLAN ON  
SEWAGE SLUDGE TREATMENT / DISPOSAL AND  
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Figure M.3  
SCHEMATIC FLOW OF MEASUREMENT AND  
ANALYSIS PROCEDURE FOR ZINC (Zn)



Note: The figure illustrates the procedure of the Reduction-Vaporization method specified in the "Authorized Fertilizer Analysis Method".











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