CSO control policy and countermeasures in Japan

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ABSTRACT

The early sewer systems were built in Japan as combined sewer system (CSS), which played an important role in urban development. In recent years, pollution of receiving waters by combined sewer overflows (CSOs) conveying large oil balls was widely reported and the Ministry of Land, Infrastructure and Transport (MLIT) addressed this issue by establishing "CSS Advisory Committee" with a mandate to report on CSS improvement in Japan. This study was followed by publications of Guidelines with Explanation of CSO control by the Japan Sewage Works Association, and amendment of Enforcement Ordinance of Sewage Law including CSO control.

To develop appropriate technologies, MLIT initiated a project called "Sewage Project, Integrated and Revolutionary Technology for the 21st Century (SPIRIT 21)". The project is operated under close cooperation among private sector, academic institutes and government. The project conducts research in the following areas of CSO treatment and instrumentation: (a) debris removal (screening), (b) high rate filtration, (c) coagulation and separation, and (d) disinfection, and (e) measurement and control instrumentation. 24 technologies were proposed in all by the private industry and proceeded to evaluation by field test in 13 cities. All technologies were tested successfully and are proposed for use in Japanese municipalities addressing CSO problems.

KEYWORD

CSO; field test; SPIRIT21

INTRODUCTION: CSO PROBLEMS IN JAPAN

In Japan, CSS were mainly adopted due to the historic background that sewerage construction was started in lower swampy zones in big cities.

CSS had been constructed mainly in big cities until 1950's because they can promote both flood control and the spread of flush toilets at the same time, by to collect wastewater and stormwater in one sewer at a reasonable cost. As a result, 10% of the municipalities with sewerage systems adopt CSS at present (191 municipalities). That covers 20% of all areas served by sewerage (230,000ha), 30% of all population served by sewerage. As the sewered population ratio is 75 percent, 23 percent of total population is served by CSS.

During the time, some municipalities were implementing CSO Control Projects and made some progress in the water environment.

However, in these days, mass media such as newspapers and television report widely on the issue of untreated wastewater overflowing from CSS in wet weather, so the untreated wastewater, which was not taken up as an issue before, is now recognized as a social problem.

For a specific example, in 2000, a large number of oil balls that flowed out of combined sewers drifted and reached Odaiba Seaside Park in Tokyo Bay, which is considered an entrance to our country. This was widely reported and had a great impact on people who naturally regard the sea as clean.

COUNTERMEASURES

Advisory Committee

With these situations, the MLIT organaized “the CSS Advisary Committee” in 2001, that surveyed CSOs of 13 major cities in Japan and completed a report on the basic concept of promoting CSO control, including the following three objectives to be attained within approximately ten years.

1. Reduce pollutant loads form the combined sewer systems to less than equivalent amount of pollutant loads from the separate sewer systems.
2. Halve the number of times of untreated wastewater overflow from stormwater outlet.
3. Prevent debris overflow from stormwater outlet.

A five-year national goal was set to increase CSO abatement ratio from 15% (2003) to 40% (2008).

New Establishment for Improvement Works

In 2002, the Japan Sewage Works Association issued “Guideline and Explanation for CSO Control”, that was followed by “CSO monitoring manual” by JIWET in 2003.

MLIT started “Urgent Subsidy for CSS improvement” in 2002, that requires municipalities to submit “CSO urgent improvement plan” to MLIT by Mar.2005.

Technology Development

In 2001, new national R&D scheme named SPIRIT21 was established, an acronym for Sewage Project Integrated and Revolutionary Technology for the 21th Century, under that R&D on the most important issues of sewage works will be done comprehensively and intensively in partnership of five groups: MLIT, Academic institutions, Municipalities, Private sector, and JIWET as coordinator. SPIRIT21 Committee was formed in JIWET to discuss important matters including theme and evaluation of technologies. And in May 2002, as its first theme, “CSS Improvement Technology” was selected.

Regulation

Enforcement Ordinance of Sewerage Law was amended in September 2003 and enacted in April 2004. In the revision, structure of outlet facilities and effluent quality standard were stipulated and are to be fulfilled within 10 years, with exception of some large cities within 20 years (see Fig 1.).

All storm overflow chambers should have appropriate weir height and device to reduce debris, and overall BOD from all outlets should be 40mg/L or less (70mg/L up to 2014) and so on.

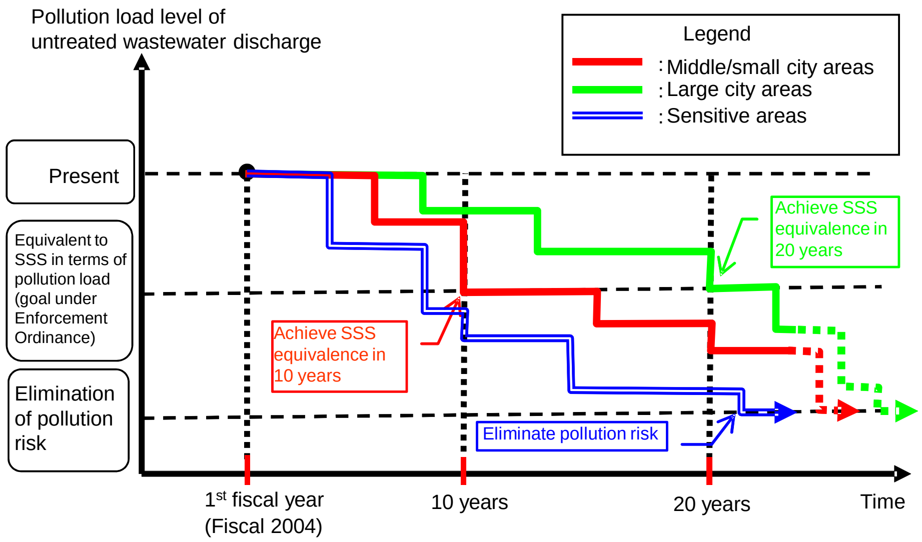


Fig 1. Image of pollution load reduction related to CSO control projects

SPIRIT21 "CSO Improvement Technologies"

As the first theme of SPIRIT21, "CSO Improvement Technology" was announced by MLIT. It was devided into 4 categories: debris removal, high rate filtration, coagulation/separation and measurement/control & disinfection, and their development target (minimum performance) for each area was set by the SPIRIT21 Committee (see Table 1). R&D is to be carried out by 4 "R&D subcommittees" along with each area, and are to be evaluated by "CSS Technology Management Committee" under the"SPIRIT21 Committee". All work were scheduled to be completed in 3 years by Mar. 2005.

Table 1. development target (minimum performance) of SPIRIT21 CSS Improvement

(1) Impurities removal technology	・ In CSS, reduce unpleasant material (wastes such as toilet paper, the men origin, various Sanitary goods, the food residues and container/wrapping) exhausted from the outlet or pump station at rain. SRV (Screenings Retention Value for impurities of 5.6mm or more) should be 30% or more.
(2) Removal technologies of pollution materials such as SS and BOD	・ Exceed the pollution removal performance of the prior technology (rain water precipitation pond), BOD 30% and SS 30%.
(3) Disinfection technology of exhaust water from pump station etc.	・ Achieve the number of of E. coli bacteria group of the exhaust water 3,000/cm^3 or less. ・ The time to achieve the effect of disinfection should be a short time. ・ As a result of disinfection, the influence on aquatic living thing of the downstream should be smaller than the prior technology.
(4) Measurement of water quality	・ Measurement item: BOD, SS, COD, T-N, T-P, and turbidity, etc. ・ Technology that can record measurement continuously and accurately

24 technologies by 24 private companies (at present 23 due to a merger) were selected by the SPIRIT21 committee to be researched and evaluated. From local government, 17 cities participated and 13 cities offered sites for research and field test (see Table 2).

By last February, the development target has been achieved by all 24 technologies, those are to be shifted to practical use in sewage works. "The Technical Document Committee", that is also under "CSS Technology Management Committee", compiles technical documents for planning, designing and operation for each technology in Japanese. They were published by JIWET.

Table 2. List of CSO control technologies

Technology category	No.	Technology	Technology proposed by	Site City
Debris Removal (Screen)	1	Hydroclean Brush Screen	KUBOTA	Osaka
	2	Rotamat RMK1 Screen	Nishihara Env. Tech.	Tomakomai
	3	CSO Screen	Sanki Eng., NIPPON STEEL, Nihon Inka, JFE Eng., Hitachi Plant Eng.	Sendai
	4	Disc Screen	Hitachi Kiden	Kyoto
	5	Storm Screen	Hitachi Kiden	Kyoto
	6	Ultra Fine Screen using perforated panel with tapered holes	Ataka Const. Eng., Kobelco, Hitachi Plant Eng., Maezawa	Nishinomiya
	7	The Copa Raked Bar Screen	Mitsubishi Kakoki	Chiba
	8	Rotary Screen	ISHIGAKI	Higashi Osaka
High Rate Filtration	9	Wet-weather high-speed wastewater filtration system	NGK INSU.	Yokohama
	10	High-Rate Filtration with a Synthetic Media	Mitsui Eng. Ship.	Kawasaki
	11	CDS Screen and the high-rate filtration method using specially-processed fibers of a material.	TSUKISHIMA, UNITIKA	Kyoto
	12	Super-High-Speed Fiber Filtration for Untreated Combined Sewage Water Overflow on Rainy Days	ISHIGAKI, Kurita, Kobelco, Sanki, Sumitomo Hvy Ind., Hitachi Plant Eng., Maezawa, NIPPON STEEL	Okayama
	13	High Rate Filtration Process	Hitachi Plant Eng.	―
Coagulation/ Separation	14	ACTIFLO PROCESS	EBARA, Nishihara, Hitachi Plant Eng., Maezawa	Fujisawa
	15	High Rate Coagulation System using CDS Screen(FSS System)	Ataka, TSUKISHIMA	Kawasaki
Disinfection	16	Effective disinfection system with chlorine dioxide	KUBOTA	Tokyo
	17	CSO DISINFECTION SYSTEM BY MEDIUM-PRESSURE UV LAMPS	TSUKISHIMA	Kawasaki
	18	Rapid Disinfection of Combined Sewer Overflow using Chlorine Dioxide	JFE Eng.	Yokohama
	19	Rapid Disinfection Technique Using High Concentration Ozone for Combined Sewer Overflow	Mitsubishi Elec.	Yokohama
	20	BCDMH Disinfection	EBARA	―
	21	The economical ozone disinfection system by using ozone adsorbing technology	SHOWA ENG.	Hiroshima
	22	Ultraviolet disinfection system	Nishihara	Tokyo
Measurement/ Control	23	Organic pollutant monitor(UV meter)	MEIDENSHA	Chiba
	24	Automatic coliform counter	MEIDENSHA	Chiba

Outline and performance of developed technologies

(a) Technologies for debris removal

There are 8 technologies, all screen, for the debris removal. 5 are for the storm overflow chamber and 3 for the pumping station.

As the result of the field test, all 8 achieved more than 60%SRV.

(i) Example of technology for the storm overflow chamber

"The disk screen" is a screen to be set up on weir in storm chamber (see Fig 2.). It has a mechanism that the things caught are returned to the inflow side by the rotation of the disk. SRV of this screen was 82% in Kyoto city.

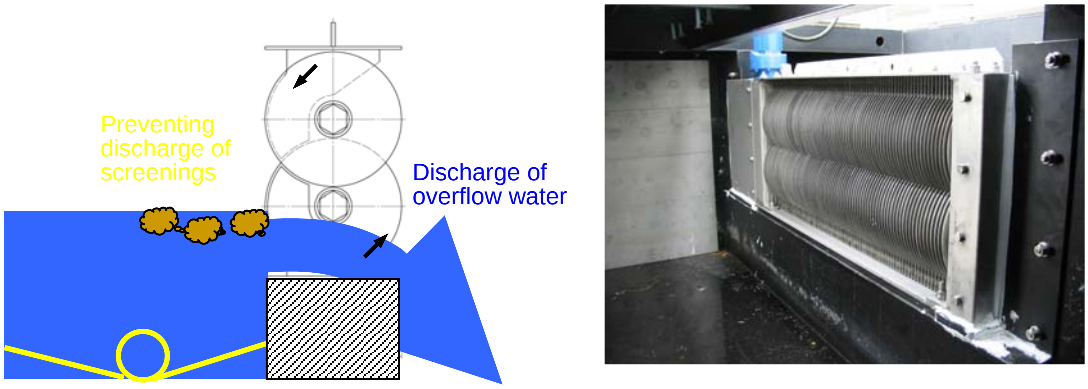
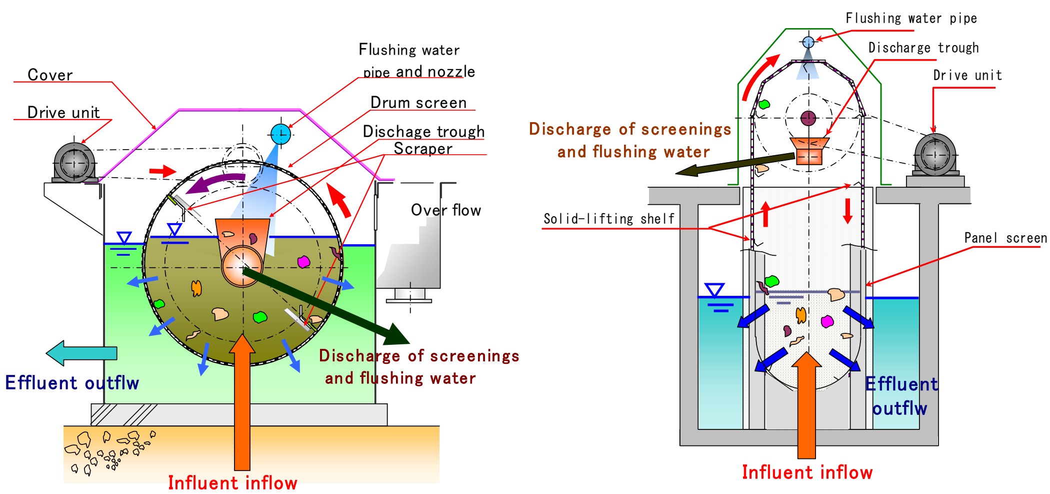


Fig 2. the Disk Screen

(ii) Example of technology for pumping station

"The rotary screen" is a screen for pump station (see Fig 3.). There are two types (the drum rotation type and the panel running type). Impurities caught inside the screen are raised up and, when reached on the top of rotation, flake off from the screen by the rinse water, and are collected in the drain trough. The SRV of this screen was 97% in HigashiOsaka city.



Drum-rotating type
Resin plate of SUS bake Tingmetal of ϕ 5 ㎜ hole

Panel-running type
hex-head opposite ϕ 5 ㎜ hole

Fig 3. the Rotary Sceen

(b) high rate filtration and coagulation/separation

There are 5 technologies of the high rate filtration, and 2 of coagulation/separation including those for adding to or refit of sewage treatment plant and those for adding to pump station.

As the result of the field test, all 7 achieved removal rate of more than 50% of BOD and 60% of SS.

(i) Example of high rate filtration

"The High Rate Filtration" using a special filter media removed more than 70% of SS and 50% of BOD at the filtration speed of 1000m/day, about 10 times theat of conventional stormwater settling tanks (see Fig 4.).

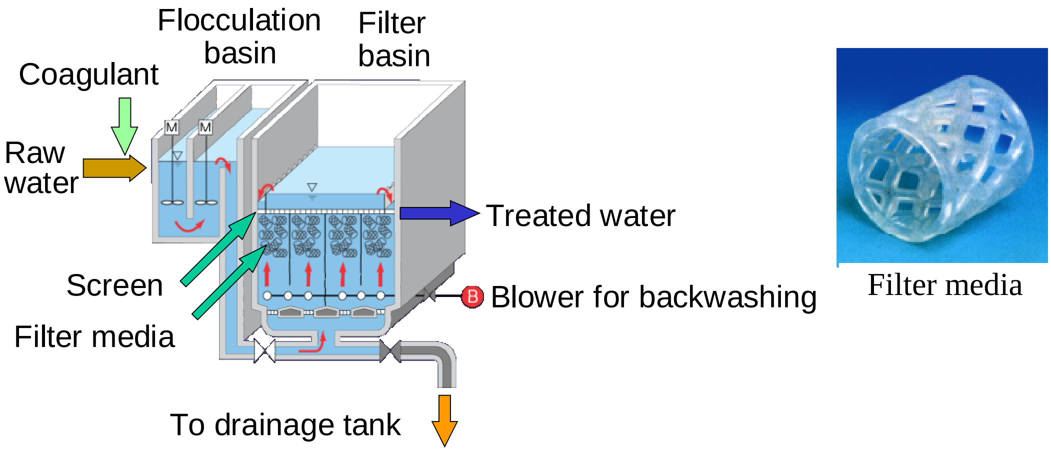


Fig.4 the High Rate Filtration

(ii) Example of coagulation/separation

"Actiflo Process" using microsand removed more than 75% of BOD, 80 % of SS and 80% of T-P in .Fujisawa. with 1/20 space of a conventional stormwater tank (see Fig 5.).

Achieve the number of of E. coli bacteria group of the exhaust water 3,000/cm3 or less.

・ The time to achieve the effect of disinfection should be a short time.

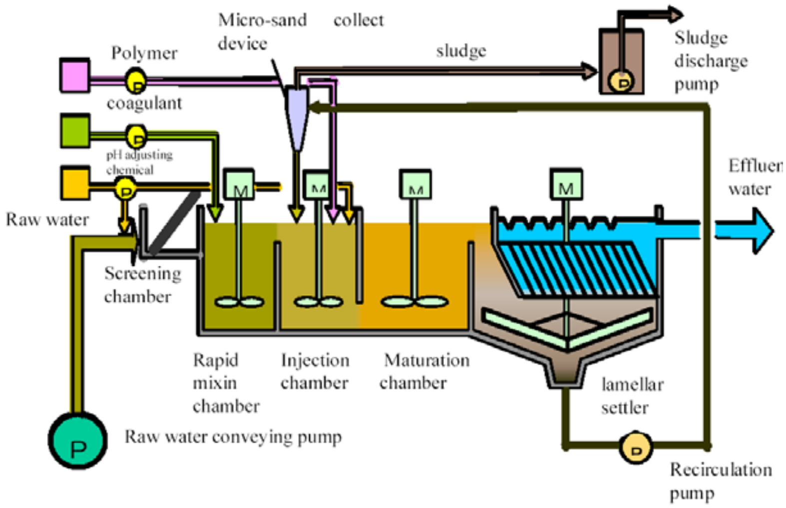


Fig 5. Actiflo Process

(c) Disinfection

There are 7 technologies for disinfection : 2 using chlorine dioxide, 1 bromine, 2 UV and 2 ozone.

All 7 required less than 1/3 disinfection time of conventional chroline method (15min) to achieve the number of of E. coli bacteria group of the exhaust water 3,000/cm^3 or less, with less influence on aquatic living thing of the downstream should be smaller than the prior technology.

(i) Example of disinfection technology using bromine-based disinfectant

Effective in 5min. about 1/3 reaction time of conventional chlorine disinfection.

(d) measurement/control instrumentation

(i)Soaking type ultraviolet rays absorbance meter

This technology, detecting ultraviolet rays absorbance and visible optical absorbance, measures COD and SS continuously and with high accuracy.

The time base range is admitted to obtain a High correlation with the hand analysis value was obtained within the following range, COD 0～150mg/L, SS 0～400mg/L.

(ii) E.coli bacteria automatic weighing device

This device adopts the unique method based on a principle quite different from a past culture method, measuring the coliform bacteria count by applying the enzymatic immunoassay (The Enzyme Immuno Assay method: EIA method)

- The measurement time: The measurement in 30 minutes is possible.
- High and low limit value within the range of detection(30 minutes in detection time)
- The number of E. coli bacteria group 66,000-8,750,000/cm3

EVALUATION

Through the new national R/D scheme “SPIRIT21” in Japan, 24 technologies were tested in 13 cities and evaluated to achieve the development target .(minimum performance) of each categories.

8 screening technologies all removed more than 60% of debris(5.6mm or more).

5 hige rate filtration and 2 coaguration/sedimentation technologies achieved double removal rate of stormwater tank, that is more than 50% of BOD and 60% of SS with less than 1/10 space.

7 disinfection technologies required less than 1/3 of reaction time to make the number of E. coli bacteria group in the exhaust water 3,000/cm^3 or less, with the influence on aquatic livingthing of the downstream smaller than the conventional chroline method.

1 measurement technologies can record measurement of COD and SS continuously and accurately. Another can measure E-coli. Group in30min.

Table 3. Evaluation of CSO control technologies

Technology category	Conventional technology	Evaluation results (general)	Number of places employed	Unit number employed
Debris Removal (Screen)	○Debris smaller than bar space cannot be removed.	○60 to 100% of debris larger than 5.6mm (unpleasant for scenery) can be removed.	267	312
High Rate Filtration	○Approximately 30% of BOD and SS can be removed by primary sedimentation. ○Design surface loading is about 150 to 300m^3/m^2・day.	○30 to 70% or more can be removed for SS with filtration velocity of 1,000 to 3,000 m/day. ○Removal of BOD and debris has been identified.	9	11
Coagulation/ Separation	○Approximately 30% of BOD and SS can be removed by primary sedimentation. ○Design surface loading is about 150 to 300m^3/m^2・day.	○60 to 75% or more can be removed for BOD and 80% or more for SS. ○80% or more can be removed for T-P. ○Removal of COD and N has been identified.	5	6
Disinfection	○It is impossible to deal with large fluctuation of flow rate and water quality. ○Design detention time for chlorination is 15 minutes.	○The standard for coliform group count, 3,000cm^3, can be achieved with one-third (5 minutes) or less disinfection.	10	35
Measurement /Control	○It is impossible to deal with large fluctuation of water quality of discharge on rainy days.	○SS, COD and coliform group count can be measured automatically and consecutively in short time.	0	0
Sum total			291	364

(at the end of August 2010)

CONDITION of IMPROVEMENT of CSSs

30 municipalities (about 16% of 191 municipalities planned) have not implemented the improvement project according to the plan. (see Fig 6.) Those need to reexamine the urgent improvement plan that applies new technology such as SPIRIT21 and realizes lower costs for improvement measures, and to complete the improvement measures within the limited time mandated by law.

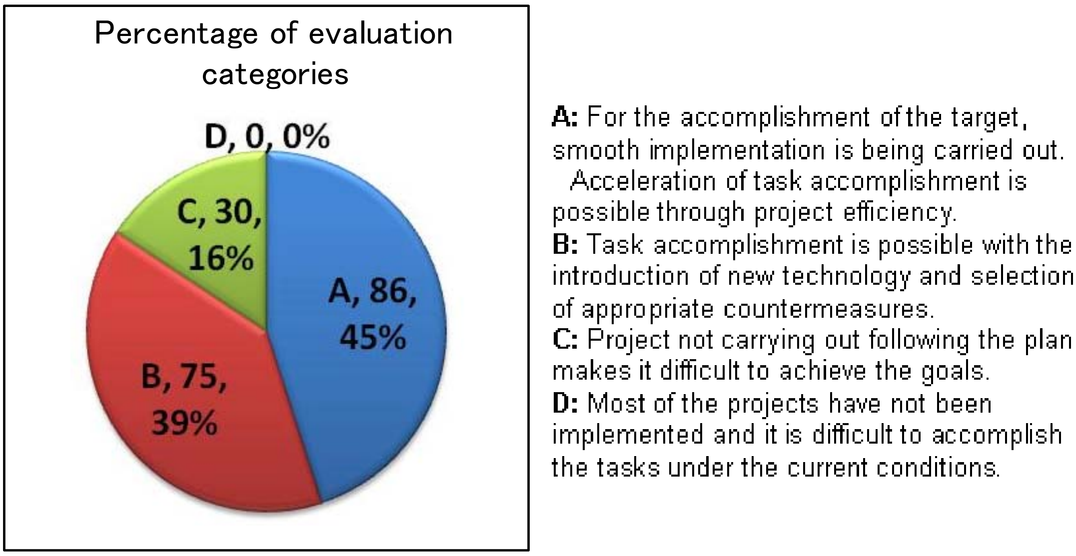


Fig 6. Condition of improvement of CSSs

RESEARCH about CSOs in NILIM

We have developed the WSD Model that is a distributed pollutant load runoff analysis model that is available for free.

The WSD model that has been developed is a distributed pollutant load analysis model that can analyze five water qualities (BOD, COD, SS, T-N, T-P). It is an economical model because its source code will be released to the public without charge, and it is easily modified by users, but challenges with analysis conditions and its operating properties remain.

REFERENCES

Sewage works in Japan 2004　JSWA
SPIRIT21,http://jiwet.or.jp/