Wastewater Technology in Japan

Japan Sewage Works Association

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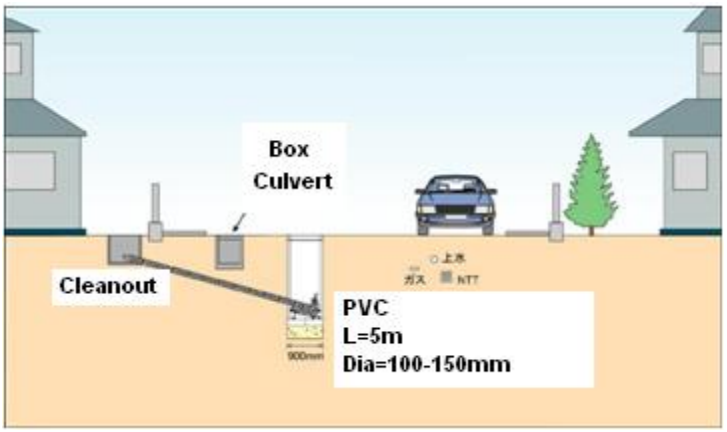
Foreword

Many locals and internationals say little information is available about Japanese technology in English. We have not made enough effort. So I decided to write this document as I am in charge. Please note the selection of technologies subjects to my own view and knowledge.

1. Installation of Sewerage

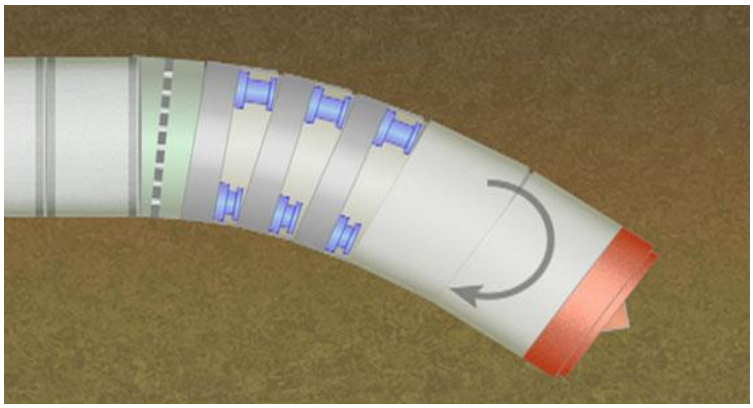
The key point is to minimize disturbance to the society. We have needed to install sewers after motorization times came. Wastewater utilities are not allowed to excavate busy streets. Under this situation, trenchless installation technologies have been widely used. Commonly used technologies are jacking and shield tunneling with segment lining.

In the case of jacking, the longest sewer installed by jacking reaches 1.5km(1,640yd) and the biggest diameter is 4,000mm(13ft)[1]. On the other hand, even the smallest lateral sewers with 150mm(5.9in) in diameter are installed by jacking in some cases[2].



Sewers are installed after water, gas, and gully at deeper underground. Open cut installation needs temporary relocation of other utility lines. Therefore, trenchless can be economical in some cases.

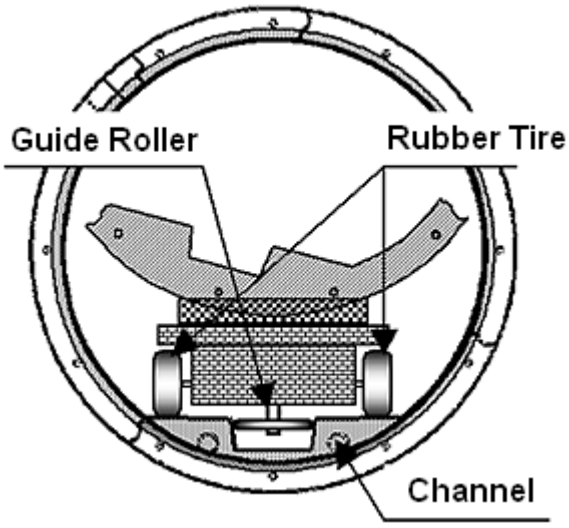
Installation under curbed road is also common practice. Less than 20m of radius for curvature has been implemented[3].

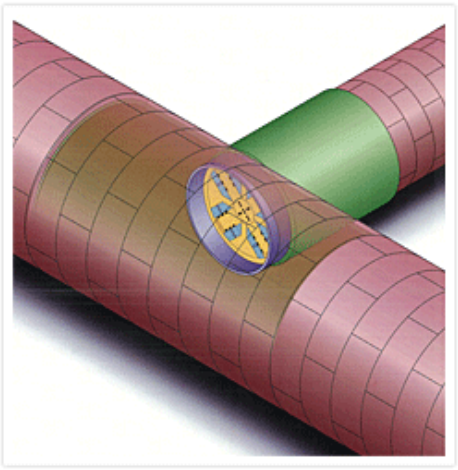


RC box culvert is installable by jacking with curbed line[4]. In separate sewer system, the storm sewer is sometimes a box culvert.

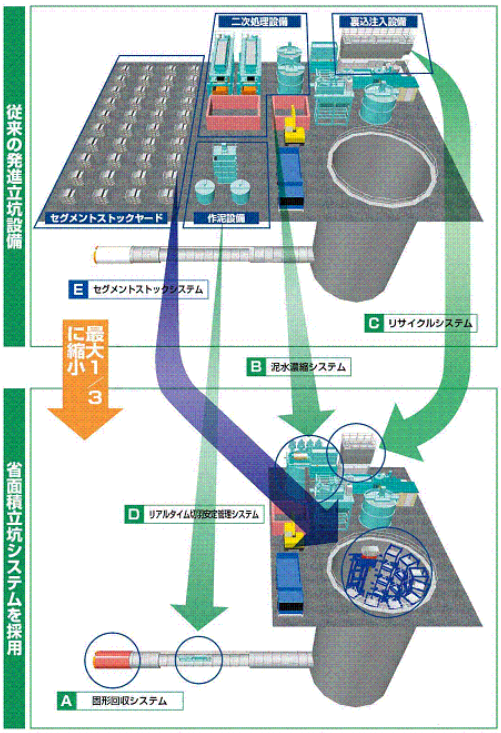
There are a variety of tunnel boring machines with patented technologies. Ideally, sewers should be installed as part of land development project by open cut method with small cost. However, in reality, in the downtown of urban cities, it is impossible to redevelop the city where lots of houses and businesses are already in place. Trenchless technology is indispensable.

Shield tunneling with segment lining is not exclusive for sewer installation. But the majority of projects in Japan are for sewer installation followed by river channel and water supply[5]. Customized methods for sewers have been developed. These include compacting by 30% of section area[6] and T connection of two tunnels[7].



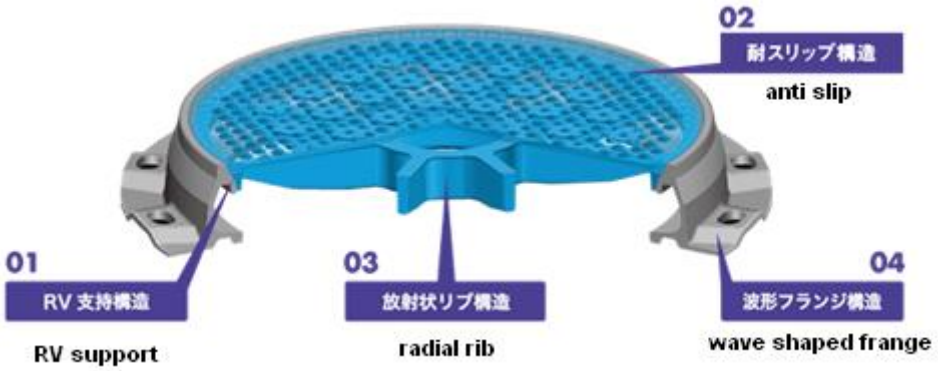


Shafts are also targeted for innovation. Compact and less disturbing installation methods of shafts and their yards have been developed and extensively used[8)9)].



Underground may have abandoned structures like steel sheet pile for past works in urban areas. These disturb smooth progress of trenchless sewer installation. To solve this problem, an innovative tunnel boring machine was developed. It identifies the underground obstacles, solidifies the surrounding ground, and then cuts them by jetting for their removal[10].

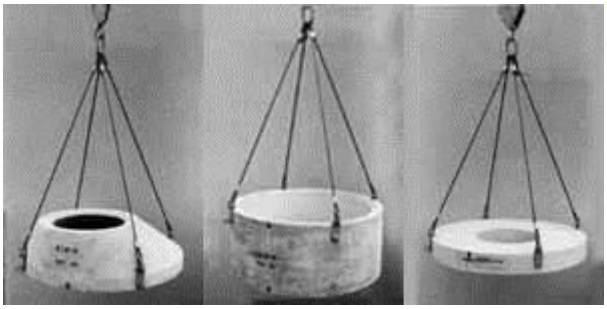
Manhole covers have been innovated to meet the tough requirements of utilities and their customers. Fundamental requirements are prevention of rattling, strength, easy opening, and prevention of slipping[11].

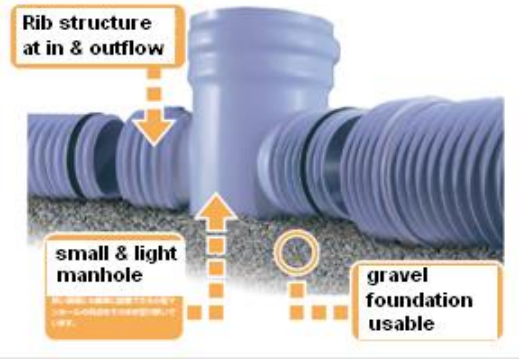


Another issue of manhole cover is how to ensure the safety to the public when sudden storm produces rapid inflow and compressed air pressure from inside. If manhole cover is completely air & water tight, the covers are blown with surrounding concrete slabs. It injures people on the road. If the covers are loose, they are blown up. The blown up covers are danger while manholes without covers posing another danger. In the past, unseen manhole without cover under the flood drowned people by their falling. Manhole covers need to be fastened to the slab while having function to dissipate

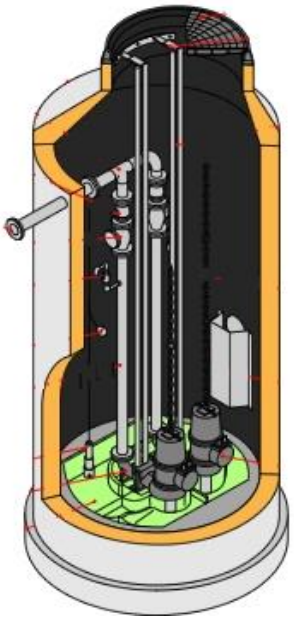
pressure inside in the sudden inflow event[12].

Manhole used to be constructed on site in the past. However, this takes long period. Nowadays, factory made manholes are installed with minimum disturbance to the society[13][14].

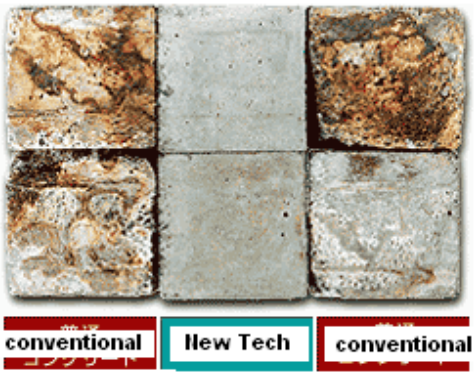




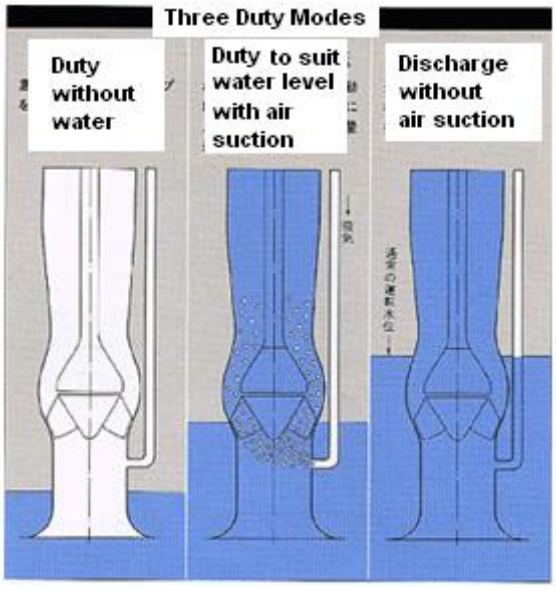
In small sewerage system in rural areas, manhole pumps are placed in the precast manholes in order to reduce the cost of sewer installation. As sewage is collected by gravity, sewer line runs deep as it goes. This leads to high installation cost. Under this case, manhole pumps are used. One type of manhole pump enables prevention of scum in the manhole[15].

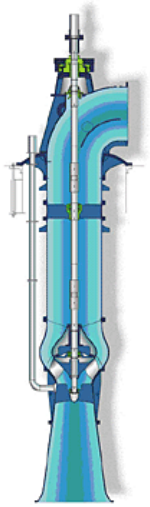


Concrete is strong, inexpensive and with less carbon footprint compared with PVC. However, it is weaker to chemical attack of hydrogen sulfide than PVC. To deal with this problem, innovative anti bacterial additive was developed. Manufacturers of concrete products have started using this to make them durable[16].



The Japanese climate from June to September is marked by hot, wet weather brought by tropical airflows from the Pacific Ocean and Southeast Asia. These airflows are full of moisture and deposit substantial amounts of rain when they reach land. Urban areas need sewerage system to drain the runoff. In lowlands, pumps are needed. In recent years, urban heat wave and climatic changes have brought sudden thunder storms in higher frequencies and extremes. Those sudden thunderstorms causes difficulties in pump operation because the water level surges very suddenly in-sewer. When pump operators were late to start the pumps, the drainage area got flooded. And when they started the pumps well before the water's surge to prevent flooding, the pumps were likely to break leading to expensive repair. To deal with this, a new type of pump has been developed. It can wait in duty mode for sudden water surge without the cooling system for bearing[17)18)]. This new pump realizes reliable pump operation and reduces flood risks.

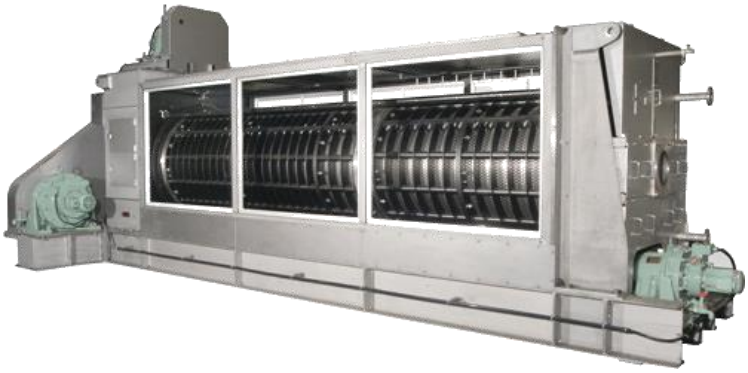




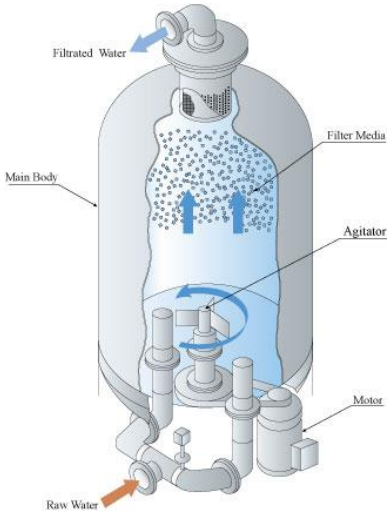
1) http://www.suisinkyo.or.jp/index.html
2) http://www.netlaputa.ne.jp/~tyk/index.htm#top
3) http://www.cosmic.gr.jp/
4) http://www.alpha-civil.com/box.html#box1-4
5) http://www.shield-method.gr.jp/jiseki/22/22graph.pdf
6) http://www.compact-shield.com/gaiyo/index.html
7) http://www.penta-ocean.co.jp/business/tech/civil/shield/t_boss.html
8) http://www011.upp.so-net.ne.jp/art/index.html
9) http://www.areasave.jp/
10) http://www.do-jet-kouhou.com/index.html
11) http://www.kouhinigm.jp/kouhinigm/index.html
12) http://www.city.sayama.saitama.jp/kurashi/sumai/jogesuido/gesuidou/hisanntounituite.html
13) http://www.unihole.jp/index.html
14) http://www.kubota-ci.co.jp/products/sewage/manhole/character.html
15) http://www.kubota-pump.com/uniholepump/spec.html
16) http://www.bic.gr.jp/index.htm
17) http://www.hitachi-pt.co.jp/products/si/pump/technology/lowcost/standby.html
18) http://www.kubota-pump.com/catalog_pdf/011.pdf

2. Treatments of Water and Sludge

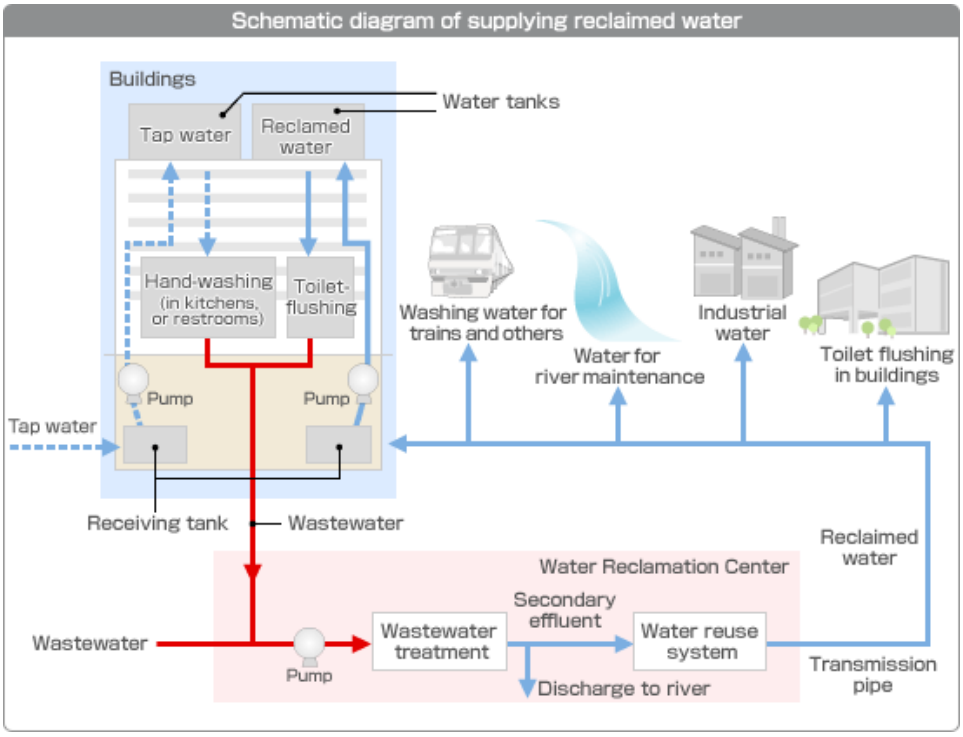
For sludge dewatering, screw press is selling well. Polymer coagulant is added to the feed sludge. After this, rotating screens thicken the sludge. Then, the sludge is mixed with another coagulant before having screw press dewatering. The system is in air tight casing for odor free environment[1)].



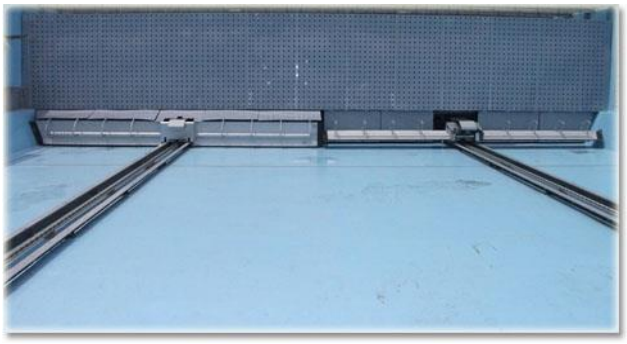
Japan is not seeking for wastewater reclamation as intensively as water scarce countries like China and Singapore because our water resource situation is better. However, in some areas, there are droughts. In other areas, sustainable water resource management is pursued in redevelopment projects. Those municipalities use reclaimed wastewater. The main use is toilet flush. The major problems they faced are mosquito and color. Reclaimed wastewater used to be sand filtrate of secondary effluent. Mosquito eggs and larva come through the sand filtration to filtrate. They hatch in the reservoirs and flush water tanks of customers and the hatched mosquitoes disturb the customers. As a solution, a fiber media filtration system has been used. This fiber media system is compact because of high filtration speed and easy to maintain[2)]. Backwash can be done with filter influent and mechanical agitation.



Another issue was yellowish color of reclaimed wastewater. It is uncomfortable for toilet users to see yellowish water on the bowl. Ozone is used to remove the color. In Tokyo, in order to reclaim water effectively and efficiently, ceramic membrane filtration is used following ozonation due to its high durability[3].

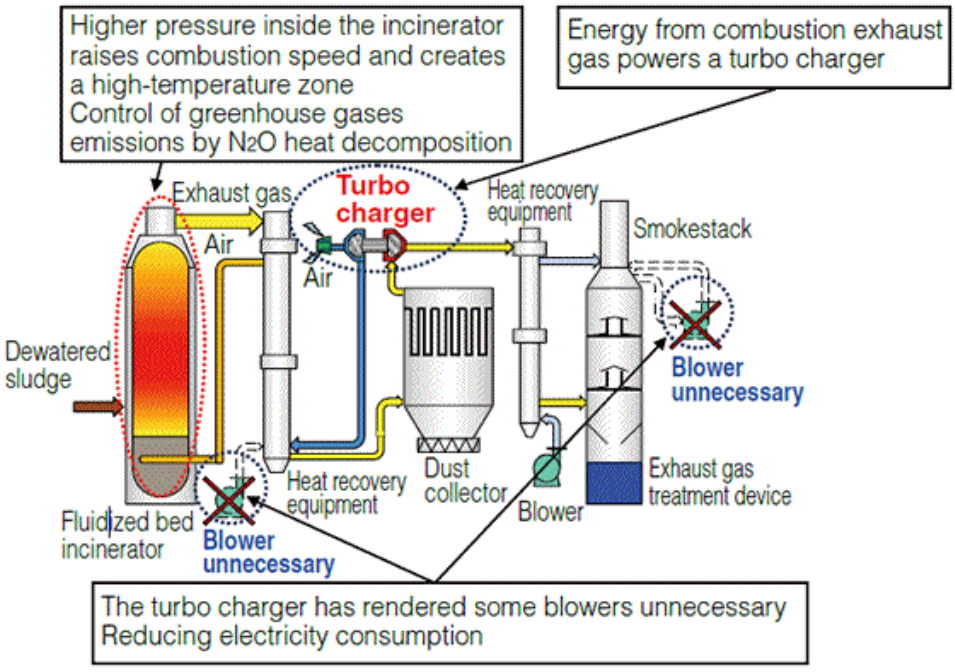


One of the most fragile components of wastewater treatment plants is sludge collector. Majority of sludge collectors are flight and chain. Chains tend to break as they age. A new type of sludge collector, monorail sludge collector, was developed and has been selling well. It is structurally simpler than chain and flight and easier to install in the sedimentation basins[4].



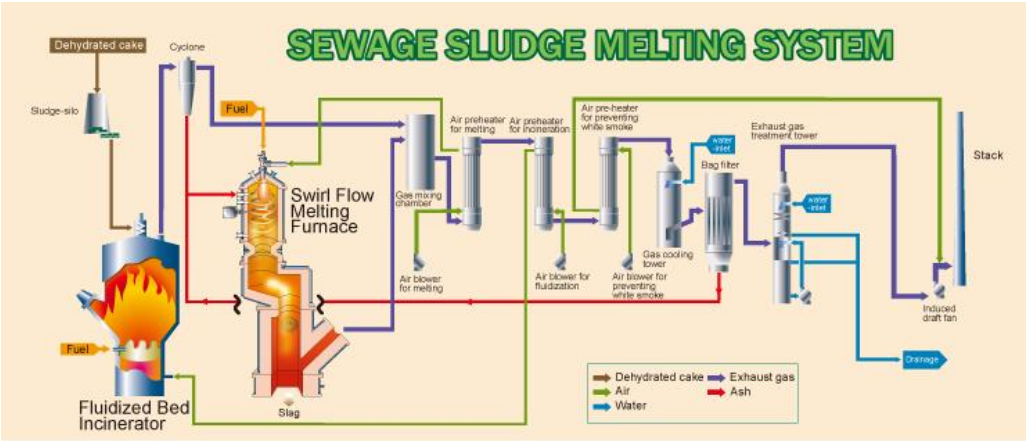
Diffusers have been getting a lot of attention as energy cost becomes higher. Membrane diffusers are getting popular of late. However, some earlier products needed high pressure to diffuse fine bubbles. This counteracts energy save. Moreover, partial replacement of diffusers was difficult when the diffusers are placed on the same air pipe line with the same blower pump. Under this, a new product of membrane diffuser was developed. Its pressure loss is almost the same as conventional ones. This product uses EPDM as material. It does not get wastewater backflow into the diffusers when the aeration is on halt[5].

In urban cities, sewage sludge is incinerated. It is necessary to prevent odor problems and reduce the volume. How to enhance the energy efficiency and reduce GHGs like N2O has been a major issue. To this end, turbo incineration system was developed. It reduces electricity use by 40%, fuel use by 10% and N2O emission by 50%[6][7].



In recent years, new law enacted to require power companies to use clean energy source. In line with this trend, a new technology was developed to put sewage sludge into biochar. It is used at coal fire power plant[8]. Several facilities are under operation and others are under construction or planning. Biochar does not smell at all. It acts as carbon neutral fuel and as carbon negative if it is buried underground.

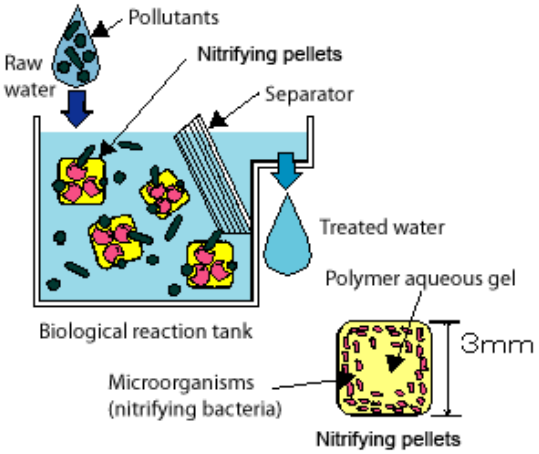
Another recycling method for wastewater sludge is melting into slag[9]. This is energy intensive but it reduces heavy metal leach and the volume of by-products or slag is smallest compared with other thermal treatment. Incineration reduces dewatered sludge by one-eighth and melting by one-twenty fifth in volume. Slag is easily recycled as construction material.



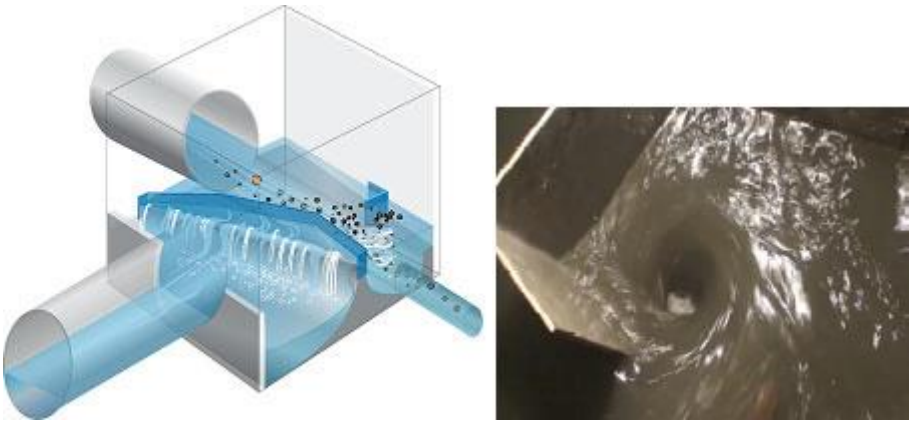
Biogas has not been used so much in Japan as incineration has been the pillar of sludge treatment. Anaerobic digestion reduces the calorie of sludge. It leads to addition of more fuel for incineration. However, recent global warming issue has pushed governments to tap into organics of biomass. One famous project is in Kurobe City. It combines sewage sludge and food waste from factories to produce biogas. The project is underway as 15-year PFI contract and the construction was complete in May, 2012 [10].

Another PFI project on biogas reuse started in Yokohama city in 2008. It will last until 2030. The SPC generates 26,319MWh/yr using the biogas provided by Yokohama City[11]. Five sets of biogas generators are used[12].

Now our water is much cleaner than it used to be. For example, in some inland seas, seaweed farmers complain about lack of nutrients due to expansion of sewer networks and improvement of effluent quality. They say low nutrient level causes poor harvest. An unfortunate exception is Lake Kasumigaura. It is the second biggest lake in Japan. Lake Kasumigaura is in the north east of Tokyo. Its water has been suffering from eutrophication due to the urbanization and farming in its watershed. To cope with this, the wastewater operator, Ibaraki Prefectural Government, introduced several types of nutrient treatment processes for their WWTPs. Among them, it says the best treatment performance for nitrogen is gained from a process combination of modified Bardenpho and moving bed with carrier called PEGASUS[13][14]. It boasts 89% of nitrogen removal.

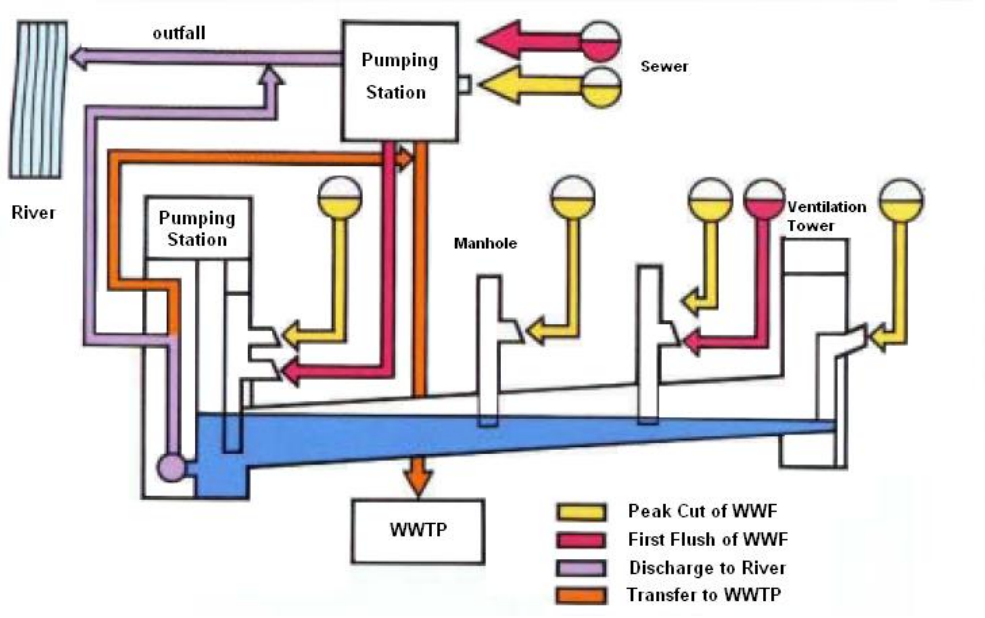


Around 200 cities use combines sewer system. CSO has been one of their major concerns after national government started regulation on CSO in 2003. One of the new requirements was the installation of controls for floatables. To do this economically and sustainably, a new type of baffle system was developed. It contains floatables into interceptor sewer leading to WWTPs. It removes floatables from CSO by creating vortex with sewage flow and baffles[15]. It is power free system unlike mechanical screen system. It has been widely used nationwide.



Apart from floatables, basic policy of CSO control is to reduce the BOD load from combined sewer system to the level of separate system. To achieve this, the fundamental solution is to store CSO in wet weather and send it to WWTPs in dry weather. To store CSO, storage sewer are constructed under the roads as open space is not available. Another issue in wet weather is control of urban flood. It is also controlled by storage sewer. Until recently, storage sewers for urban flood control and CSO control have been installed separately. This is because real time control was

difficult. For CSO control, first flushing of wet weather flow needs to be stored while peak wet weather flow needs to be stored for urban flood control. Kawasaki City made a success in controlling CSO and urban flood for the first time in Japan by single storage sewer by introducing Toshiba control system[16)17)]. The diameter of storage sewer is 10.4m(34ft), which is the largest in Japan.



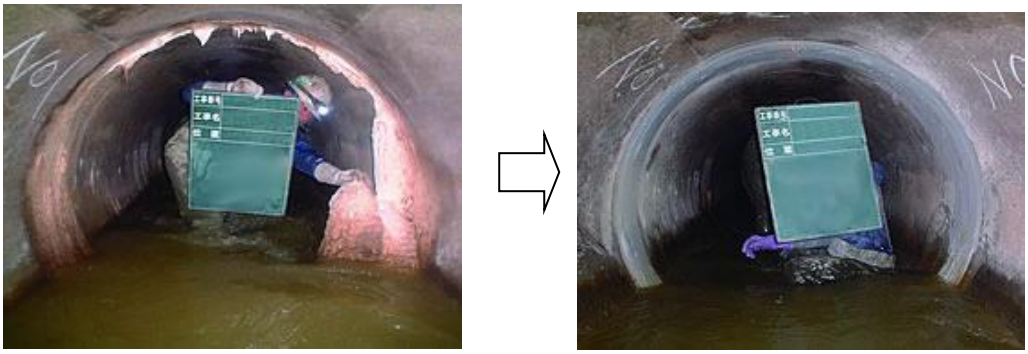
1) http://www.ishigaki.co.jp/english/Products/Filter/Detail/ISGK3.html
2) http://www.ishigaki.co.jp/english/Products/Filter/Detail/IFW.html
3) https://www.metawater.co.jp/eng/product/wastewater/reuse/index.html
4) http://www.fj-i.co.jp/monore/mono.htm
5) http://www.daicen.co.jp/perlcomb/mempanel.html
6) http://togesui.com/english/ourprofile/ourprofile11.htm
7) http://www.tsk-g.co.jp/tech/eco-jouge/deido/shokyaku04.html
8) http://www.tsk-g.co.jp/tech/eco-jouge/deido/odei.html
9) http://www.kobelco-eco.co.jp/english/BusinessContents/Melting/q1.html
10) http://www.swing-w.com/business/topics/hdmob6000000074c.html
11) http://www.city.yokohama.lg.jp/kankyo/kisha/h21/091218-1.html
12) http://www.jfe-eng.co.jp/products/environment/pdf/CA4124.pdf
13) http://jcma.heteml.jp/bunken-search/wp-content/uploads/2007/09/019.pdf
14) http://www.hitachi-pt.com/products/es/water/wastewater/pegasus.html
15) http://www.n-koei.co.jp/news/pdf/110914.pdf
16) http://www.city.kawasaki.jp/80/80syomu/home/book/pdf/mizunomamori.pdf
17) http://www.toshiba.co.jp/sis/page/1_1_2_03.htm

3. Maintenance & Rehabilitation of Sewer

The most vulnerable component of sewerage are the laterals that connect sewer main to individual property or catch basin. It is installed close to the surface of roads and other utility lines. It is damaged easily by heavy traffic and excavation works by other utility operators. Broken laterals suck surrounding soil leading to sinkholes on the pavements. To prevent this threat to urban city, a new radar system was developed. It searches the cavity of ground around the laterals[1].

SPR is the innovative trenchless sewer rehab technology. It rehabilitates any shape of sewers while sewage running. It is used worldwide[2].

If a man-entry sewer line suffers infiltration on a limited part, a new type of leak control has been getting attention. Sealant and lining material cures in water as long as the water is still[3]. It has 0.3 MPa water pressure resistances. This technology needs skill of worker but is sure way to stop leakage.

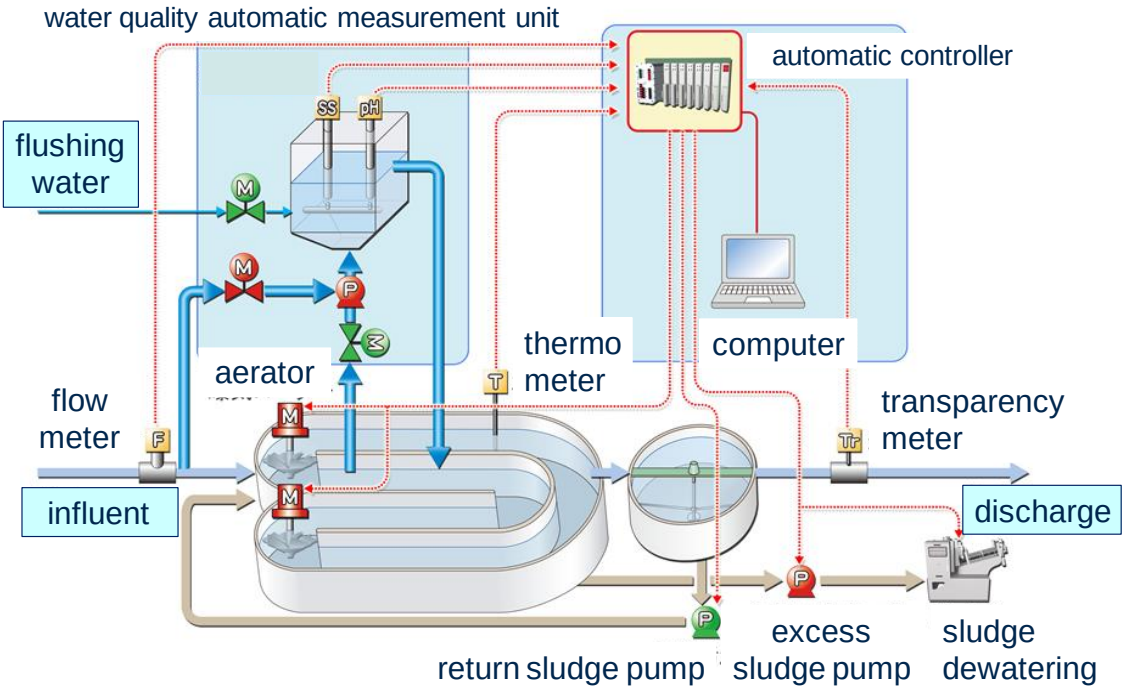


FOG in the deep manhole is really a big problem.　Jetting cannot work.　To remove solidified sediments with FOG at the bottom of deep manhole, special excavation machine was developed.　It is used to maintain sewer capacity in Tokyo[4)]

1) http://www.tgs-sw.co.jp/technical/contents/index4_27.shtml
2) http://www.sekisuispr.com/public/spr/en/technology/wickelrohr/col4/0/download/SPR%20Technologies.pdf
3) http://www.crystal-l.com/intro2.html
4) http://www.gesui-mente.or.jp/works/index.html

4. Operation of WWTPs

In Japan, oxidation ditch is the most common treatment method in rural area[1]. It has been designed and built by Japan Sewage Works Agency[2]. A lot of expertise has been gained for designing, building, and operation. Recently, an automatic control system was developed for producing good quality of effluent with less energy use. The idea is not feed back but feed forward by measuring water parameters in the influent and reactor to know the oxygen demand[3][4][5].



1) http://gcus.jp/wp/wp-content/uploads/2011/10/Data-of-Sewage-Works-in-Japan.pdf

2) http://www.jswa.go.jp/english/index.html

3) http://www.jswa.go.jp/g/g2/pdf/116.pdf

4) http://mono-ch.nikkan.co.jp/m/enterprise/2011/01/post-338.html

5) http://gcus.jp/wp/wp-content/uploads/2011/10/Advanced-Oxidation-Ditch-Process-and-Screw-Press-Dewatering.pdf