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Water and Sewer Treatment Technology in the World and Trends in the Privatization of Public Water Utilities

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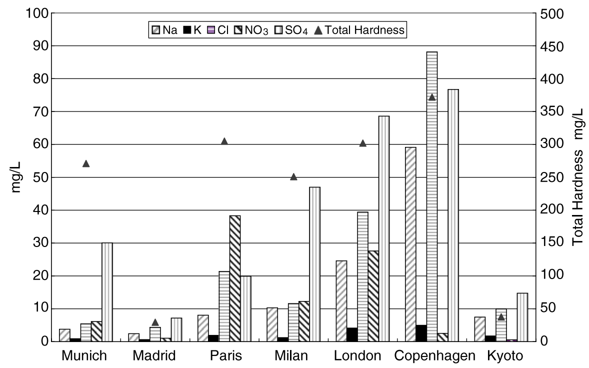
1 Introduction

As a matter of course, water is indispensable to all forms of life; it is a decisive element in sustaining life. There has been a growing interest in water around the world. For instance, the industrialized countries face a pressing need to upgrade and replace aging water/sewer lines. Water pollution is looming large in China, in which air pollution has been considered a major environmental threat - a national project is underway in Lake Taihu (located on the outskirts of Shanghai), where there is a massive outbreak of blue-green algae due to the continuous inflow of domestic and industrial wastewater[1]. The developing countries, meanwhile, are saddled with serious problems such as extreme water shortages and the lack of water infrastructures due to fund shortages - in addition to public funds, development projects funded by industrialized countries are indispensable to solving these problems.

The privatization of public water utilities has been underway in Europe, into which big companies are making inroads. These companies are also extending their reach into other areas such as energy and telecommunications, pushing ahead with their diversifying strategies. Underlying this trend is a growing attention to the promising infrastructure market, which has been monopolized by municipalities. Furthermore, they are now poised to branch out into other countries, taking advantage of expertise (in services, etc.) obtained on their home grounds. Based on the recognition of these trends, this report addresses the present status of water utilities and water treatment technology in each of the countries concerned.

Figure 1:Concentrations of inorganic ions in tap water in major cities



Source: Author's compilation based on data quoted from http://www.jousui.com

2 The status of water treatment technology

Only a few countries including Japan seem to have the habit of drinking tap water as it is, while the majority of countries and regions in the world boil it before drinking. Naturally, water treatment technology varies from place to place since water quality is unique to each country and region. Figure 1 shows the concentrations of inorganic ions in tap water in major cities of the world[2].

2.1 Recent trends in water and wastewater treatment

The safety of water is becoming a big concern in urban and industrial areas where water pollution from hazardous substances and bacteria is becoming increasingly serious. In these areas, water sources are closely monitored for possible

Table 1:Water treatment technology

	Treatment Technology	Objective
Clean/Tap Water	Chemical treatment, membrane filtering, ultraviolet treatment, ozone treatment, chlorination, activated carbon treatment	Removal of floating/soluble materials, disinfection, sterilization, removal of carcinogens
Sewer/Wastewater	Activated sludge treatment, membrane filtering, ultraviolet treatment, ozone treatment, chlorination, activated carbon treatment	Removal of floating/soluble materials, disinfection, sterilization, removal of carcinogens
River/Lake Water	Biofilm treatment, filtering, membrane filtering	Removal of floating/soluble materials, nitrification of ammonia nitrogen

contamination. With this situation as a backdrop, municipalities managing water are showing more interest in advanced water purification systems that are safer and more efficient than conventional ones.

Japan was originally blessed with water of good quality and abundant water sources. Not many people were buying bottled mineral water or teas about 20 years ago. However, it is now becoming a common practice to boil tap water before drinking, and an increasing number of households are installing water purifiers. In addition, those who prefer bottled mineral water to tap water are on the rise.

Ensuring the supply of tasty water inevitably involves conservation of water sources, but the realities are that a number of problems are emerging: eutrophication in water sources (lakes, reservoirs, rivers, etc.) resulting in a bad odor in tap water, ground water pollution from organic chlorine compounds, and generation of trihalomethanes during the water purification process. Worse yet, more chlorine is added to water to prevent contamination from E. coli O157[*1] and other pollutants - which ruins the taste of tap water. These problems cannot be solved overnight; what is needed is a concerted effort among all the parties concerned, that is, the government, municipalities, private companies and local residents.

2.2 The status of water treatment technology

With water quality varying from place to place, a variety of methods are in use to treat water (see Table 1).

Coagulation, sedimentation, filtering and disinfection are the basic processes of treating water and sewer. These processes are designed to remove impurities, but cannot remove musty odors. New treatment methods replacing chlorination, meanwhile, are being developed in Japan in the wake of an accident in which tap water was contaminated with cryptosporidium[*2], a protozoan organism that can survive chlorination.

Because of the need to reduce musty odors from tap water, municipalities in the Kansai region have long been addressing advanced water purification technology. The then Ministry of Health and Welfare mapped out "Guidelines for the Introduction of Advanced Water Purification Facilities" in March 1988, launching a government subsidy system in an effort to support public water utilities in setting up advanced facilities. The guidelines define "advanced water purification facilities" as "activated carbon, ozone, and biological treatment facilities that treat impurities such as odorants, trihalomethane precursors, pigments, ammonia nitrogen and anionic surfactants, all of which cannot be treated by conventional processes." The objective: solve existing problems by adding one or more advanced water purification facilities to operating facilities[3].

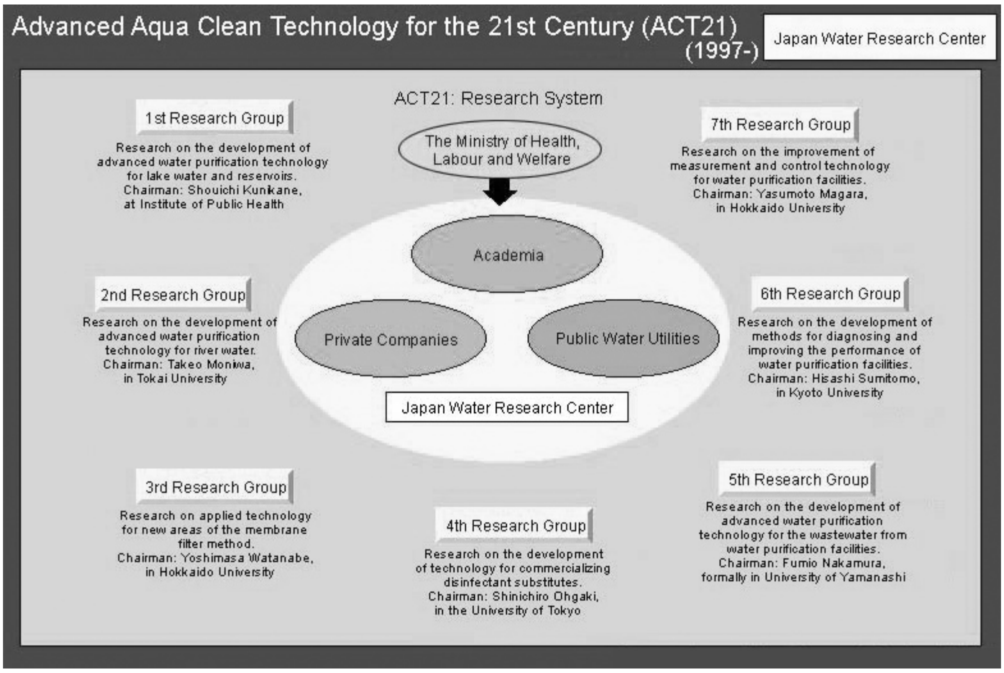
As part of this project, R&D efforts have been underway, funded partly by a health-science research budget. For instance, a five-year program with a budget of some 1.3 billion yen was launched in 1997: Advanced Aqua Clean Technology for the 21st Century (ACT21). Under the initiative of the Japan Water Research Center (JWRC), universities along with a total of 45 private companies took part in the program (see Figure 2[4]).

Advanced water purification systems remove organic matters in water, using less chlorine. These systems incorporate "biological treatment," "ozone treatment" and "activated carbon treatment" into conventional water purification processes to further improve the quality of treated water - organic matters are removed to the maximum extent possible, along with nitrogen, phosphate and endocrine disrupting substances, each of which cannot be fully removed by conventional processes. Figure 3 shows an example of advanced water treatment (some processes such as injections of pH adjusters are omitted from the process flow[5]).

Biological treatment is a water purification process in which microorganisms decompose or coagulate impurities in water. This treatment uses less chlorine for disinfection purposes since it can remove ammonia nitrogen and odors quite effectively. The biological treatment of advanced water purification systems includes the submerged filtration method (using honeycomb media), the rotary disk method and the biological contact filter method. In addition, a method combining biological treatment and activated carbon treatment is already in practical use. Because of its porous structure, activated carbon has a high specific surface area, offering an ideal habitat for microorganisms that in turn provide activated carbon with biological treatment capabilities. Activated carbon equipped with these capabilities is called "biological activated carbon," and the treatment using this type of activated carbon is referred to as "biological activated carbon treatment." This advanced treatment is receiving attention as a new process that can be applied to processes in which activated carbon treatment precedes chlorination[3].

Ozone treatment is designed for disinfection, deodorization and decoloration purposes. Activated carbon treatment, though, is needed after ozone treatment to remove by-products produced from ozone oxidation. Ozonizers that can generate high concentrations of ozone need to be developed to reduce the high costs of ozone

Figure 2:Advanced Aqua Clean Technology for the 21st Century (ACT21)[3]



Source: Japan Water Research Center (JWRC)

Figure 3:Example of advanced water purification system

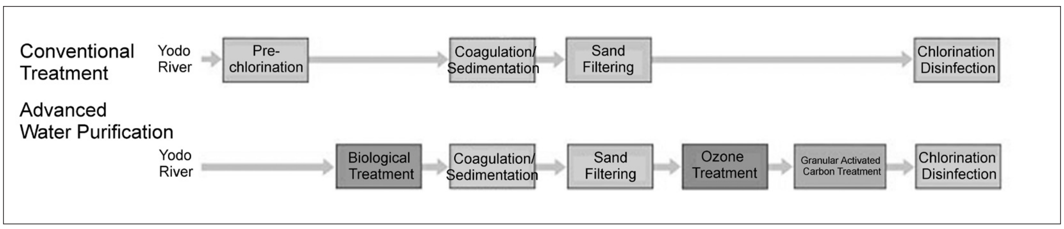


Table 2:International conferences on ISO/TC224

Date	International Conference	Subject
Apr. 2001	Proposed by France	International standardization of water/sewer services
Sept. 2002	The 1st ISO/TC224 Conference in Paris	Presentation of suggestions, scheduling
Jan. 2003	The WG4 Conference in Vienna	Discussions about water/sewer systems, presentation of Japan's plan
Mar. 2003	The Paris Conference (WGs)	Counterproposals to the secretariat's plan, presentation of Japan's plan
May 2003	The WG4 Conference in Lisbon	Discussions about water/sewer systems, presentation of Japan's plan
Jul. 2003	The WG3 Conference in Banff, Canada	Discussions about water/sewer systems, presentation of Japan's plan (service guidelines)
Sept. 2003	The 2nd ISO/TC224 General Conference in Ottawa	International standards (draft), determination of a general framework
Sept. 2004	The 3rd ISO/TC224 General Conference in Marrakech	Presentation of international standards to member countries, approval procedures
Jul. 2006	ISO/TC224 International Standards	Slated to come into effect

treatment[6, 7].

Activated carbon, because of its absorptive properties, is effective in removing odorants, trihalomethanes, total organic halogen compounds and trace hazardous chemicals such as agrochemicals. Activated carbon recycling plants (facilities that recycle used activated carbon through the heating method) have already been commercialized - an economical option for water purification facilities using a large amount of activated carbon.

More than 70% of trihalomethane precursors can be removed by these biological, ozone and activated carbon treatment methods, which together contribute substantially to reducing chlorine dosage. Likewise, more than 90% of surfactants, which cannot be treated by conventional treatment, can be removed.

3 Progress in international standardization efforts

France recently proposed the "standardization of service activities relating to drinking water supply and sewerage" to ISO. The objectives: address possible water shortages in the future and set out guidelines for water and sewer services that offer quality services at reasonable rates. If the standards stipulated in the proposal are adopted "as is" as international standards, however, Japan may have to revise its own standards. In addition, companies in a country whose domestic standards are similar to ISO standards may gain a competitive edge in branching out into other countries. These factors are expected to have a substantial impact on the operation and maintenance of Japan's water and sewer system, the total cost of which stands at some 3 trillion yen a year. A domestic task force, therefore, decided to actively participate in the preparation of international standards and has made a number of suggestions through international conferences (see Table 2 for details).

On the domestic front, moreover, there is a move afoot to set out domestic service guidelines to streamline domestic public water utilities and to ensure the transparency of their services - an effort in response to ISO/TC224 (Standardization of Service Activities Relating to Drinking Water Supply and Sewerage). International service guidelines of this kind would help each public water utility analyze its management status both at present and in the past, and quantify the quality and efficiency of its services - which would lead to improving the public water utilities themselves.

Another reason why ISO/TC224 is attracting the attention of those engaged in water and sewer services is its relation to WTO. ISO standards are voluntary standards in the first place, and hence the adoption of these standards is left to the discretion of each company/utility concerned. Possible agreements on environmental services through the ongoing inter-governmental negotiations on WTO services, however, would create a new framework - i.e., according to the WTO-TBT Agreement (an agreement that precedes any relevant domestic laws, where international standards are available), both the government and municipalities must comply with applicable international standards when handing out contracts (totaling more than 21 million yen for the government or 33 million yen for municipalities)[8].

What would then be the situations in other countries? The following chapter addresses other countries' water and sewer systems and their management statuses.

4 Water and sewer services and technology in other countries

4.1 Germany

Ozone treatment, using ozonizers developed by Siemens, has long been in use for disinfection purposes in Germany. Among natural substances, ozone is the most powerful oxidizer next to fluorine; it decomposes naturally into oxygen with no residual toxicity. Because of these properties, ozone is widely used for deodorizing and decolorizing water and air, as well as for disinfection/sterilization purposes by enhancing biodegradability against persistent organic matters. It is also used for disinfecting swimming pool water - a total of 1,057 swimming pools were disinfected with ozone in 1983. Ozone is generally used in combination with activated carbon. Figure 4 shows the interior of a typical ozonizer. The German government is currently making efforts in conserving water sources. Incidentally, tap water is not chlorinated in the country.

As for privatization movements, RWE (a leading electricity and gas supplier in Germany) bought out Thames Water (a leading water supplier in the UK), and is poised to extend its reach into the world infrastructure (water and sewer) market. In September 2001, moreover, the company bought out American Water Works (the biggest water-service company in the U.S.) for 912 billion yen. The North American market is estimated at 10 trillion yen a year, and projects worth 60-120 trillion yen are expected for the improvement and replacement of aging water and sewer lines.

Figure 4:Interior of a typical ozonizer

4.2 France

While advanced water purification and membrane treatment are widely practiced in France, this section addresses other technological trends, presenting specific examples.

Biological treatment is receiving widespread attention in France as an ecological option. This particular treatment, which involves a wastewater purification system using biotechnology developed in Germany in the 1960s, has been in operation for about 10 years; it takes advantage of the purification capacity of bacteria, purifying wastewater by means of plants without using any electricity or chemical treatment. Biological treatment is also becoming widespread in other countries such as the U.S., the UK, the Netherlands, Denmark and Austria. The number of projects involving biological treatment has increased from 20 to some 100 over the past five years in France. Although this technology is designed to treat domestic wastewater from small households, R&D efforts are underway for applications to industrial wastewater.

In France, a major part of water business is run by small municipalities - about 75% of which is outsourced to private companies. Specifically, a system called "concession·affermage" is in place; it leaves basic management authority to municipalities or public corporations (i.e., they manage assets and assume management responsibilities), while outsourcing operations to private companies. Currently, the top three companies - Vivendi, Suez and Saur - together account for some 90% of the domestic market. Those who have accumulated expertise and capital, both of which are indispensable for water business, gain a competitive edge in the market. The rates of privatization stand at 78% for water systems and 74% for sewer systems in France. Vivendi, meanwhile, fully took over PVK (a water/sewer service company based in Prague), which indicates that the company is gaining a stronger foothold in the European market[9]. The French government, however, has begun to discuss policies for water services to address regional disparities in the quality and rates of water - a growing trend due to the privatization. In response to EU's decision on the framework of water services, the Minister for Ecology and Sustainable Development, who takes charge of the policy-making, has held a series of meetings to discuss in detail policies for water services in France, inviting representatives from all sectors of society (government, industry, academia, citizens, etc.) and gathering opinions both on a national and regional basis by means of dialogues and questionnaires through the Internet[10].

4.3 The United Kingdom

In the UK, UV-radiation has long been a common treatment for disinfecting swimming pool water. Being particularly effective in killing viruses, UV-radiation treatment has become widespread across the country to prevent polio infection. UV rays, which have no residual toxicity, are effective in killing E. coli, bacteria, fungi, yeasts and viruses; they produce no hazardous substances such as trihalomethanes, and, hence, have a negligible impact on the quality of water. Specifically, UV-radiation treatment is a method in which UV rays disinfect (in a matter of seconds) the water passing through devices. The chlorination method was later developed to make up for the shortcoming of this treatment - i.e., UV rays cannot penetrate turbid water. In the 1960s, however, ozone treatment began to take over the method combining UV-radiation and chlorination since the latter produces trihalomethanes as byproducts[11].

Scotland previously experienced an outbreak of cryptosporidiosis - an accident attributable to tap water - that raised havoc not only with local residents but also with a water supplier because of the lack of an appropriate communication system. While the UK water business had been run by 10 public water utilities until 1989, the operations of water services were subsequently outsourced to private companies due to a shortage of public funds for capital investment. And Thames Water (UK), which originally held a dominant share of the privatized market, was later bought out by RWE (Germany) in January 2000. The privatization rates are now close to 100% in the UK[12].

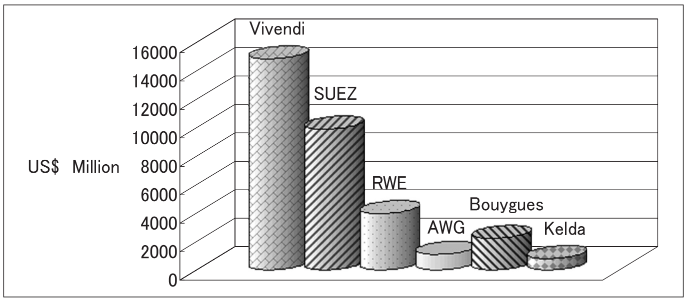
4.4 The Netherlands

KIWA Water Research is a Dutch institute primarily engaged in research on water, the environment and energy. Its specific activities include: surveys and control of the quality of drinking and industrial water, environmental research, surveys of human resources for water services, services related to pipeline construction, and information services[13]. In particular, a national initiative is underway to improve the quality of water. Nuon, a Dutch company providing electricity, gas and water services, bought out a leading US water-service company in early 2001. Overall trends in the Netherlands are similar to those in France.

4.5 The United States

Lagging far behind its European counterparts, the U.S. set out guidelines for ozone treatment in 1986. Although funds and demand for water/sewer systems were on the rise in the country due to stricter water quality regulations and aging water treatment facilities (which together fueled demand for improved water/sewer systems), the need arose in 1990 to capitalize on private funds since federal subsidies were abolished. In 1992, the Federal Government stepped up a tax preferential system for public facilities, extending its period from 5 to 20 years. In April 1999, Vivendi (France) bought out US Filter (the No. 1 water service company in the U.S.) for 972 billion yen. In June 1999, Suez (France) took over Nalco (the No. 1 manufacturer of water treatment chemicals in the U.S.) and United Water (the second largest water service company in the U.S.) for a total of 612 billion yen. These buyouts symbolize the growing presence of European companies in the US market, which situation suggests that they have strengthened their control over the world water market. In fact, Vivendi, Suez, and RWE (Germany) combined account for more than 80% of the world's

Figure 5:Sales of water treatment companies



Source: Materials provided by Mr. Kazunari Yoshimura

privatized market for water and sewer services, which covers some 360 million people in 130 countries - the market is increasingly dominated by these three companies. Figure 5 shows the sales of each major company's water treatment business.

Because of the deregulation policy to introduce private funds into public utilities, the privatization rates in the U.S. currently stand at 35% for water services and 28% of sewer services. On the other hand, there has been a particular case where a contract for the privatization of water/sewer services was canceled. The incident took place in Atlanta: in 1997, the municipal government signed a contract worth 22 million dollars with United Water for its services to be provided for 20 years. With the services privatized, the operational costs were reduced from 50 million to 22 million dollars. However, it turned out later that the deterioration of water/sewer lines was worse than originally expected, with inaccurate statistical figures surfacing one after another. For instance, the municipal government originally reported that a total of 1,200 water meters needed to be repaired or replaced; the actual number reached 11,200. Likewise, damaged parts of water/sewer mains increased from 100 to 280, and malfunctioning hydrants, from 730 to 1,630. In addition, other costs related to labor unions and default payments stood at as much as five million dollars for municipal facilities alone. Due to this series of false descriptions, United Water eventually cancelled the contract in January 2002. The municipal government, therefore, ended up paying 48 million dollars to place the services back under its management - a serious blow to both the municipal government and United Water.

A bill for investing a total of 25 billion dollars in water/sewer services in five years has recently been presented to the House of Representatives. The objectives: evaluate and analyze the vulnerabilities of water/sewer lines, discuss innovative methods to alleviate a shortage of funds for the infrastructure, conserve water sources, regulate emissions of new pollutants and improve the infrastructure as needed. As for chlorine used for advanced water treatment technology, regulations for the byproducts of germicides and disinfectants are also presented as a priority issue.

G. Tracy Mehan, III (Assistant Administrator of the Office of Water, EPA) announced recently that a national program is under study at EPA to promote water-efficient products. As water shortages, if not drought, are expected in more than 36 states in the decade ahead, they are becoming the focus of increasing attention in the U.S. The program is designed to improve the efficiency of water usage by disseminating information about water-saving products, encouraging manufacturers to produce more water-saving products, and supporting wholesalers and retailers in promoting sales of those products[14].

5 Conclusion

Being blessed with water of good quality and abundant water sources, Japan is believed to have properly managed water sources and water/sewer treatment. The current situation, however, is such that treatment/management processes need to be reviewed for both water and sewer services to address a variety of problems - e.g., E. coli O 157, cryptosporidium, contamination of well water with organic chlorine compounds and arsenic, generation of trihalomethanes, contamination with foreign materials due to aging water lines, and generation of by-products associated with chlorination. Other problems inherent to water/sewer services include: aging facilities; tightening water quality standards that require improvements in technology; the need to improve management efficiencies; disclosure of information that is required; expanding service areas due to the consolidation of smaller municipalities; and sluggish revenues from water sales due to the ongoing recession. In addition, it has long been pointed out that soil pollution is contributing to groundwater pollution. A nationwide survey of the contribution rates of sewer to the water environment shows that the national average stood at 27.6% as of the end of 2002; Shiga prefecture marked the highest rate (71.8%), while Gunma prefecture registered the lowest (1.3%). The contribution rates vary substantially from prefecture to prefecture[15]. As "water" in this particular case refers to water sources, tap water, sewer, wastewater, industrial water, well water, seawater, lake water, river water, etc., with each involving its unique environment, debates over "problem-solving" are increasingly complex.

Water treatment technology has been making headway, involving technological innovation - which is symbolized by improved water quality due to the introduction of advanced water purification techniques. In response to a suggestion made by France about ISO standards, there have been active discussions in Japan on the possible adoption of international standards - the spotlight centers on water utility services. The introduction of ISO standards could further improve Japan's water quality control, which in itself is beneficial from the viewpoint of ensuring the supply of safe water.

An increasing number of public water utilities in European countries are being privatized, each of which is striving to improve services and reduce costs - the time will come soon when Japan needs to address this vital issue. When opting for privatization, however, there is a need to have a clear picture of the circumstances surrounding the domestic public water utilities, as the example of the U.S. shows.

On the other hand, growing demand for mineral water in Japan indicates that public requirements for drinking water are becoming more stringent, from "potable water" to "safe and tasty water."

In view of all these factors, what is required for water treatment technology in the future is not only to produce potable water and treat wastewater but also to improve water quality and establish technology best suited for Japan's unique nature and culture. Technological innovation should also be promoted to improve services as a whole. In solving the problems mentioned above, therefore, there is a need to monitor water sources and introduce overseas expertise in addition to adopting advanced water treatment systems. In this context, it is desirable that due attention be given to both domestic and international trends and appropriate approaches be adopted, taking into account a water cycle as necessary.

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Glossary

*1 O157

E. coli strains are ubiquitous in the intestines of livestock and humans, most of which are harmless. Some E. coli, however, are called "enteropathogenic E. coli," which may cause digestive problems such as diarrhea and complications. Among these enteropathogenic E. coli, there are strains producing toxins that cause hemorrhagic enteritis and hemolytic uremic syndrome (HUS); they are referred to as "enterohemorrhagic E. coli." These enterohemorrhagic E. coli strains can be classified according to their components (surface antigens or flagellar antigens), one of which is "E. coli O157." As E. coli O157 produces toxins that cause hemorrhagic enteritis, it is officially referred to as "enterohemorrhagic E. coli O157."

*2 Cryptosporidium

Cryptosporidium is a protozoan organism that causes a parasitic infection called "cryptosporidiosis," which results in diarrhea, stomachache, fever and nausea. As it can survive chlorination, mass infection through tap water and swimming pool water occurs every year primarily in industrialized countries. Japan, too, experienced an outbreak in 1996 that was caused by tap water.

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