Groundwater Conservation and Tap Water Management:
Experience of Kumamoto City, Japan

1 Background

Kumamoto City is located in the center of the Kyushu region. The city has a gentle plateau and plain stretching out below Mount Aso in the east and to the Ariake Sea in the west. Kumamoto city has the third largest population in the Kyushu region, next to Fukuoka City and Kitakyushu City. All water comes from groundwater. Almost all of the approximately 740,000 residents use groundwater as drinking water. This has earned Kumamoto the title "The home of the richest groundwater in Japan."

The Kumamoto Region (with 11 municipalities including Kumamoto City, a land area of about 1,041 km² and a population of about one million) is located between the western foot of the Mount Aso Caldera Rim and the Ariake Sea. Pyroclastic flows and lava from eruptions of Mount Aso were deposited in the region. Water can percolate through these layers very easily. About 400 years ago, Kiyomasa Kato, the first feudal lord of Higo Kumamoto Province, carried out paddy field development in the middle basin of the Shirakawa River which flowed through the region, as the region’s ability to permeate and recharge the local groundwater aquifer was preserved. It is said that the development made groundwater more abundantly available. Due to the soil, where water can easily percolate through, paddy fields in this region have a recharge rate five to ten times greater than that of other regions, and are therefore called “strainer paddy fields.” Water percolates through these paddy fields and flows out in the southern urban area of the city. All tap water in Kumamoto City comes directly from groundwater, which is chlorinated only at a minimum level based on tap water quality standards. Quality mineral water is always supplied as tap water, as citizens can drink "mineral water from the tap."
On the other hand, the city does not have an alternative source for groundwater, and may face a crisis when it is difficult to keep the quantity of groundwater or make water quality stable. In Kumamoto City, with rapid urbanization since the early 1970s, the use of water by citizens has increased while the quantity of groundwater has decreased. Around 2002, the groundwater environment changed greatly. To improve the environment, the city made various efforts to conserve groundwater. The city has also taken measures for groundwater pollution by business activities, and continued stable supplies of the tap water citizens can drink safely.

As a result of these groundwater conservation initiatives, the 2013 edition of “Water for Life” UN-Water Best Practices Award was awarded to Kumamoto City.

2 Policies for Groundwater Conservation

2.1 Maintaining groundwater recharge

Kumamoto City has carried out various initiatives to conserve its groundwater, including the adoption of the “Declaration of the Groundwater Preservation City” in 1976, the establishment of the “Kumamoto City Groundwater Preservation Ordinance” in 1977 and the installation of groundwater observation wells in 1986. As part of these efforts, the city has conducted research on groundwater flows. The research has revealed that one third of the groundwater recharge depends on paddy field zones in the Kumamoto Region, especially farmlands in the upper and middle basins of the Shirakawa River running through the Towns of Ozu, Kikuyo and other municipalities located on the east side of Kumamoto City. Paddy fields have decreased dramatically in the upper and middle basins of the Shirakawa River due to urbanization since the 1970s and the national rice acreage reduction policy. This resulted in a decrease in the quantity of groundwater circulation in the Kumamoto Region.

Therefore, for the purpose of groundwater conservation, the city needs to cooperate with neighboring municipalities to maintain and increase the groundwater recharge. The city formulated an agreement to maintain and increase groundwater recharge through cross-municipal cooperation. Major cooperative initiatives started in 2004. They included a project to flood converted paddy fields in the middle basin of the Shirakawa River and to maintain watershed protection forests in the upper basin.
2.1.1 **Project to Flood Converted Paddy Field**

In order to maintain the recharge from the paddy fields which are especially important to maintain groundwater quantity in Kumamoto City, the city has cooperated with the Council for Sustainable Water Use in Agriculture, which consists of Kumamoto City, Ozu and Kikuyo towns, four local land improvement districts, JA (Japan Agricultural Cooperatives) Kikuchi and JA Kumamoto City East Branch, since 2004. This project provides subsidies to encourage farmers to flood, maintain and manage their converted paddy fields with water from the Shirakawa River every day. The period is after harvesting and before planting crops for one to three months between May and October. The area flooded has increased every year as farmers and local firms have participated in the project. The flooding is effective to improve soil fertility and limit negative effects of soil pests. Local farmers have cooperated in the flooding project as part of farming.

In 2012, the “Kumamoto Ground Water Foundation” was established through integration of three organizations of the municipalities, the prefecture and the agricultural industry and the operators relative to the region. The foundation works on additional cross-municipal projects including the regional flooding project.

<table>
<thead>
<tr>
<th>Flooding period</th>
<th>Subsidy per 0.1 hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>11,000 Yen (US$91)</td>
</tr>
<tr>
<td>2 months</td>
<td>16,500 Yen (US$137)</td>
</tr>
<tr>
<td>3 months</td>
<td>22,000 Yen (US$183)</td>
</tr>
</tbody>
</table>

**Table 1 Subsidy provided by the flooding project**  
(for converted paddy fields) (source: Kumamoto City)

To ease the fall of rice prices, caused by the decline in rice consumption and surplus of rice, the government of Japan has limited areas and amounts of rice production. Farmers are forced to produce crops other than rice in their paddy fields. These fields are known as “converted paddy fields.” Converted paddy fields are not flooded when they are used for cultivation of crops other than rice. In this case, only rainwater can recharge groundwater, resulting in a substantial decrease in groundwater recharge.
2.1.2 Initiatives in Paddy Field Conservation and Agricultural Support

Rice production requires a particularly long period of flooding of four to five months. In this area (the middle basin of the Shirakawa River), the production of one kilogram of rice results in a groundwater recharge of about 20 to 30 m³. As such, it is important to encourage that rice production is continued and the farming management is stable in this area. Rice and vegetables produced in this area have subsequently been established as the “Gift of Water” brand. To encourage individuals, organizations or companies to use the “Gift of Water” products, the “Water Offsetting” program has been carried out. The paddy field owner program has been started with the aim of conserving the paddy fields which are on the decrease.

2.1.3 Maintenance and Protection of Watershed Protection Forests

Watershed protection forests, which are vital to Kumamoto City, are located in the upper basins of the Shirakawa River and the Midorikawa River outside the city (upper basin of the Kasegawa River; the Kiyama River). Like paddy fields, the maintenance of watershed protection forests requires cooperation among neighboring municipalities. Having seen the serious damage caused by the flood of the Shirakawa River in 1953, municipalities in the upper basin and those in the lower basin recognize that maintaining forests is crucial for disaster and flood prevention and therefore they help maintain the forests. After that, maintaining forests can also recharge water sources. Therefore, the municipalities have proactively worked together towards mutual benefit. To be concrete, Kumamoto City has executed forest management agreements and profit-sharing afforestation contracts with the municipalities which own forest fields in the region since 2004, on the premise that the earnings from the afforestation would be divided at a certain ratio. The city plants, grows, maintains and cuts trees. About 800 hectares of watershed protection forests were maintained and protected by 2013. The area is planned to expand to 1,000 hectares.

Water Offsetting

The estimated amount of groundwater recharged is divided by the amount of rice produced in order to derive the amount of groundwater recharged for each ton of rice produced. By buying rice grown in fields that engage in groundwater recharge, consumers can indirectly contribute to recharging a relevant amount of groundwater, thereby offsetting the environmental impact imposed by using tap water.
2.2 Initiatives in Water saving and Water Leakage Prevention

Among usages after extracting groundwater in Kumamoto City, the ratio of tap water was on the rise. As a reason, excessive extraction of groundwater for uses other than tap water, including business operators and the agriculture industry, was controlled by a notification system based on the “Groundwater Preservation Ordinance.” But, due to lifestyle changes, the use of groundwater in everyday life was on the rise. Recognizing that abundant groundwater cannot be conserved and handed over to future generations only by increasing recharge capacity, the city is raising awareness among its citizens to reduce the use of water. The city increases groundwater at the first point by water recharge while managing groundwater at the last point of water usage. The city set a target to reduce 10% of the daily use of groundwater per citizen per day (from 254ℓ in 2002 to 230ℓ on average) from fiscal year 2005. After the target was achieved in fiscal years 2012 and 2013, the city planned to reduce the amount further to 218ℓ for the next five years. Various initiatives have been carried out to boost the water saving movement through participation of citizens. The city started and operates the “Wakuwaku Water Saving Club” bringing citizens who agree with the movement together, provides visiting workshop programs at primary schools, offers water saving pieces for free, publicizes stores cooperating in the spread of water saving devices and conducts other activities.

![Workshop for water saving by municipal staff at a primary school (Source: Kumamoto City)](image)

![Figure 3 Change in the use of water by citizens (Source: Kumamoto City)](chart)
To take measures for water leakage of tap water supply and distribution pipes, the city has surveyed water leakage, and repaired or replaced the pipes in a phased manner based on the water leakage prevention plan. The effective ratio reached at 92.4% in fiscal year 2013. To improve it further, the city has determined priorities and implemented update works.

The city has worked to reuse sewage-treated water. It operates the scheme in some areas. Sewage-treated water flows from sewage clarification centers to agricultural waterways. Local farmers use the water. When water levels in rivers decrease, reusing sewage-treated water can limit groundwater extraction. The city has worked on groundwater conservation comprehensively by taking more measures to make use of water resources.

3 Proper Management of Water Quality

The city secures the quantity of groundwater by conservation measures, while selecting proper points to survey and monitor water quality routinely in order to enable the city to identify the situation of groundwater pollution and take measures for improvement in water quality early. The city also has made an effort to supply quality tap water stably by monitoring water quality in a comprehensive, continued manner at the final points where tap water users use water (number of the points and frequency of water quality checks by Waterworks Bureau: water intake wells [108 points/three times a year], water distribution facilities [41 facilities/four times a year], water plugs at parks and other locations [42 locations every month/62 locations every day]).

Among groundwater pollutant substances already detected, the city has taken early countermeasures to improve contamination by volatile organic compounds from activities at factories, offices or other entities. The city educates local offices for purification methods and storage methods of hazardous substances. From around 2004, the rise of the nitrate-nitrogen concentration became obvious. Joint research was carried out with research institutions to analyze the
It was identified that the rise caused by excessive fertilizers at dry fields and excessive reduction of non-treated livestock waste to farming fields. To solve the issue, the city developed the “Plan for the Reduction of Nitrate-Nitrogen Loads in Kumamoto City” and cooperates with farmers, the agriculture industry and academics to work on proper use of compost and proper treatment of livestock waste. In addition, the city promotes countermeasures in source origin, and is proceeding with the plan to build a facility for appropriate treatment of livestock waste in the area on the east side of the city, its important recharge area.

4 Results and Effectiveness of Projects

4.1 Conservation of Quantity of Groundwater

10 years have passed since the launch of the flooding project. Groundwater levels have increased. Water recharge is calculated from flooding paddy fields. From these factors, the flooding project is recognized to help conservation of groundwater recharge. According to the Kumamoto City Second Groundwater Conservation Plan announced in March 2014 (Heisei 26), about 300 farmers flooded 7,650,000 m³ at the time of the project launch in fiscal year 2004. After 10 years, about 450 farmers cooperate in the flooding project. Almost all of the converted paddy fields that can be utilized are flooded. Annual groundwater recharge totals about 15,000,000 m³. In addition, the water saving quantity through efforts of citizens has contributed significantly to conservation of groundwater recharge.

Kumamoto City sets a target of 30,000,000 m³ of artificial groundwater recharge. To achieve the target, the city plans to work on more cross-municipal flooding projects or other activities with the Kumamoto Ground Water Foundation.

4.2 Establishment of a Brand as the “Groundwater City”

Kumamoto City promotes the initiative to market rice and vegetables produced in the middle basin of the Shirakawa River in which groundwater is recharged effectively. The products are sold under the “Gift of Water” brand. The city positions the bottle of this free flowing well, as one of the city’s water sources, discharges 14,000 m³ of ground water at 18 degrees Centigrade every day. (Photo: ICLEI Japan)
Kumamoto’s groundwater “KUMAMOTO MIZUMONOGATARI” as an official water and distributes the bottled water at external events and conferences held in the city. The city also publicizes the importance of Kumamoto’s asset “water” in and outside the region. For example, it communicates related information on websites, registers tangible and intangible assets relative to the water in the city as the Kumamoto Water Heritage and publicizes them as tourism resources. As a result of the city’s initiatives in water resource conservation, Kumamoto City won the “10th Japan Water Prize (Japan Water Prize Committee)” in June 2008 and the 2013 edition of “Water for Life” UN-Water Best Practices Award. These initiatives are widely respected by external parties. A series of accolades helps citizens and business operators to be more aware of water saving and conservation.

4.3 Toward a Low-Carbon Society

Kumamoto City regards the groundwater conservation policy as the pillar of its strategy for low-carbon city development. Utilizing its foundation as the groundwater city, it plans to promote the flooding project further, reduce carbon-dioxide emissions through water saving activities and increase carbon sinks by maintenance and protection of watershed protection forests. The city also promotes the use of natural energy sources at water facilities. It introduces solar power generation on roofs of waterworks and water supply facilities. Small hydraulic power generation is being constructed at the Toshima Water Supply Facility. When water falls from a distribution reservoir, the difference in height generates energy. This energy is converted into electric power and utilized effectively. The purpose is to reduce environmental burdens resulting from water feed/distribution systems.

5 Lessons learned

5.1 Cross-municipal cooperation allows the use of natural systems

The flooding project of Kumamoto City was not possible without cooperation with the adjacent municipalities where paddy fields, the source of groundwater in Kumamoto City, exist in the agricultural areas. To do so, sharing the groundwater conservation policy in the Kumamoto Region and cooperation with adjacent municipalities and business operators are indispensable. Effective measures supporting local farming are also important factors for the achievements. They include subsidies and exploring business opportunities for agricultural products. Kumamoto City has solved new issues such as expansion of the flooding project and reduction of nitrate-nitrogen concentration, as it seeks a broader range of cooperation with concerned parties.
As the background of the cross-municipal cooperation, there is another important element. Kumamoto City has made an effort to solve issues through research and data accumulation for groundwater recharge and flow mechanisms with Kumamoto Prefecture. Based on the date obtained by the city’s research, the city has planned effective measures, verified effectiveness and taken other activities with cooperation with local research institutions and academics.

5.2 Promotion of Raising Awareness of Citizens

The city takes active water saving educational activities for its citizens and initiatives to establish its brand as the groundwater city. These have produced a steady water saving effect, working well on groundwater conservation. Many efforts are seen. For example, the city provides environmental education to school children and offers programs such as “Wakuwaku Water Saving Club” and “Forest Volunteers” to citizens. These activities offer continued opportunities for citizens to voluntarily understand the local resources and to be actively involved in conservation.

6 Replication

Kumamoto City has made an enormous effort to supply drinking water that is almost 100 percent from groundwater by using old wisdom about enjoying abundant, quality groundwater to conserve the surrounding natural environment. The city’s basic approach is that it can supply high quality tap water stably in a more effective way at lower costs if tap water is managed by using natural systems, compared to construction of large scale dams or introduction of high functional water purification facilities.

The city’s approach may be very helpful to other areas where building tap water systems is an urgent issue. Kumamoto City conserves groundwater recharge by taking advantage of natural systems and managing both recharge and water intake, and supplies quality water stably by proper water quality management. Especially in the areas where the population is expected to increase in the future, a great challenge is to supply water stably and effectively as the use of groundwater in everyday life and the demand for agricultural water is on the rise. Much attention is paid to groundwater as a valuable water resource especially in the areas with low surface water, such as islands. Natural systems are different in each area. Accurate research and understanding of water sources can enhance the potential to introduce and maintain tap water systems more effectively.
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