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Water Resource Utilization in Taiwan's Municipalities: A Comparative Perspective

Ts'ui-jung Liu
Academia Sinica, Taipei, Taiwan

Taiwan's administrative divisions have been changed several times throughout history. At the end of 2010, Taiwan Area (including Taiwan Island and its off-shore islands) is divided administratively into five municipalities (直轄市), three cities (市), and 14 counties (縣). And in 2014, Taoyuan County was designated a municipality because its population is over 200 million persons. With this administration division, this paper is attempted to discuss the issue of water resource utilization with a comparative perspective in the six municipalities from north to south: Taipei City (台北市), New Taipei City (新北市), Taoyuan City (桃園市), Taichung City (台中市), Tainan City (台南市), and Kaohsiung City (高雄市). Statistics of population and fresh water provision will be utilized to analyze the related issues. It is hoped that through this comparative study, the strength and limitation of each municipality in terms of water resource utilization can be illustrated and evaluated.

Keywords: Cleam Water, Taiwan's Municipalities, Population, Tap-water, Wastewater treatment

Introduction

Access to clean water is a human right. In November 2002, the UN Committee on Economic, Social, and Cultural Rights adopted General Comment No. 15 on the right to water. Article I.1 states that, "The human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realization of other human rights". *General Comment No. 15* also defined the right to water as the right of everyone to sufficient, safe, acceptable, and physically accessible and affordable water for personal and domestic uses. On 28 July2010, through Resolution 64/292, the UN General Assembly explicitly recognized the human right to water and sanitation. By a vote of 122 in favor to none against, with 41 abstentions, the UN General Assembly adopted a resolution calling on States and international organizations to provide financial resources, build capacity, and transfer technology, particularly to developing countries, in scaling up efforts to provide safe, clean, accessible, and affordable drinking water and sanitation for all. The resolution declares the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights[1].

Furthermore, "Water for Life" Decade was carried out during 2005-2015. The primary goal of the "Water for Life" Decade is to promote efforts to fulfil international commitments made on water and water-related issues by 2015. Focus is on furthering cooperation at all levels, so that the water-related goals of the

Ts'ui-jung Liu, Ph.D. Harvard University, 1974.Currently, Research Fellow of the Institute of Taiwan History, Academia Sinica, Taipei, Taiwan.
[1] Accessed on 2019/02/11, http://www.un.org/waterforlifedecade/human_right_to_water.shtml.

Millennium Declaration, the Johannesburg Plan of Implementation of the World Summit for Sustainable Development, and Agenda 21 can be achieved. The challenge of the Decade is to focus attention on action-oriented activities and policies that ensure the long-term sustainable management of water resources, in terms of both quantity and quality, and include measures to improve sanitation. Achieving the goals of the "Water for Life" Decade requires sustained commitment, cooperation, and investment on the part of all stakeholders from 2005 to 2015 and far beyond.

The "Water for Life" Decade provides an opportunity to everyone to get involved. The Decade takes place everywhere around the world. Your ideas and initiatives, as an individual or organization, are always welcomed. Whatever kind of events you decide to organize, we hope this will help you leverage the maximum impact, however modest your budget. All efforts will contribute to making the "Water for Life" Decade a landmark event![2]

With the above global background, this paper aims at discussing the issue of water resource utilization in six municipalities in Taiwan with a comparative perspective. The status of municipality in Taiwan is designated in the *Local Government Act* (地方自治法). According to the Article 4 of *Local Government Act*: "Regions of population of not less than one million and two hundred fifty thousand (1,250,000) and have special requirements in their political, economic, cultural and metropolitan development may establish special municipalities".[3]

Currently, there are six municipalities in Taiwan. They were established in different dates as follows: Taipei City (台北市) was established on 1 July 1967; New Taipei City (新北市), Taichung City (台中市), Tainan City (台南市), and Kaohsiung City (高雄市) were all established on 25 December 2010; and Taoyuan City (桃園市) on 25 December 2014.[4] This paper will use statistics of population and clean water provision to analyze the related issues. It is hoped that through this comparative study, the strength and limitation of each municipality in terms of water resource utilization can be illustrated and evaluated.

Population

The population of Taiwan Area and six municipalities at the end of 2018 are shown in Table 1.

It is notable that the population of six municipalities together makes up 69.3% of the total population of Taiwan Area. As for the population densities, Table 1 shows that six municipalities are all higher than the average of Taiwan Area (651.68 persons/km^2), and the highest density is found in Taipei City (9,818.16persons/km^2), followed by New Taipei City (1,946.69 persons/km^2), Taoyuan City (1,818.96persons/km^2), Taichung City (1,265.93 persons/km^2), Kaohsiung City (939.59 persons/km^2), and Tainan City (859.55 persons/km^2). In terms of persons per household, three municipalities are above the average of Taiwan Area (2.70 persons): They are Taichung City (2.88 persons), Taoyuan City (2.75 persons), and Tainan City (2.73 persons), while Kaohsiung City (2.52 persons), Taipei City (2.53 persons), and New Taipei City (2.56 persons) are below the average.

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[2] Accessed on 2019/02/11, http://www.un.org/waterforlifedecade/background.shtml.

[3] Accessed on 2019/01/31, https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=A0040003.

[4] For the date of becoming municipality, see the website of each City Government. Taipei City: https://www.gov.taipei/cp.aspx?n=30893B06044587E0; New Taipei City: https://www.ntpc.gov.tw/ch/home.jsp?id=52; Taoyuan City: https://www.tycg.gov.tw/ch/home.jsp?id=33&parentpath=0,6; Taichung City: https://www.taichung.gov.tw/8868/9945/10011/676408/post; Tainan City: https://www.tainan.gov.tw/cp.aspx?n=13291; Kaohsiung City: https://www.kcg.gov.tw/cp.aspx?n=07880B28C8E3EAEA. All accessed on 2019/01/30.

Table 1

The Population of Six Municipalities in Taiwan at the End of 2018

	Land area		Population		Population density	Persons per household
	(km^2)	%	No. persons	%	Persons/km^2	
Taiwan Area	36,197.07	100.00	23,588,932	100.00	651.68	2.70
Taipei City	271.80	0.75	2,668,572	11.31	9,818.16	2.53
New Taipei City	2,052.57	5.67	3,995,717	16.94	1,946.69	2.56
Taoyuan City	1,220.95	3.37	2,220,872	9.41	1,818.96	2.75
Taichung City	2,214.90	6.12	2,803,894	11.89	1,265.93	2.88
Tainan City	2,191.65	6.05	1,883,831	7.99	859.55	2.73
Kaohsiung City	2,951.85	8.15	2,773,533	11.76	939.59	2.52

Source: *National Statistics, ROC* (中華民國統計資訊網), https://www.stat.gov.tw/ct.asp?xItem=15408&CtNode=3623&mp=4(accessed on 2019/02/11).

Water Sources of Tap-Water for Six Municipalities

According to Taiwan Water Cooperation (TWC), regarding water sources, most people are under the common impression that the rainfall in Taiwan is quite abundant every year. The fact is that most of the rainfall is rapidly lost to the ocean due to strips of populous areas, the abrupt geographical features of Taiwan's mountains and torrid downpour. According to statistics of rainfall in the major countries in the world, the mean rainfall per year in Taiwan is approximately 2,510mm (approximately 90.4 billion cubic meters). It is triple that of the global average. However, due to land formation and Taiwan's population, the estimated amount of utilized water is only 18.4 billion cubic meters. This calculation makes Taiwan's utilized water only reach the seventh of the world average. In Taiwan, usable water resources are not fully utilized. Water shortages continue to occur due to the unequal distribution of rain, as rainfalls during the rainy seasons are incomparable to that during the drier seasons. According to world standards, a country or region is considered an arid region when the water supply in the region per person per year is 1,000-2,000 tons. Taiwan belongs to an arid area because the usable rainfall per person per year is only about 1,000 tons. In addition, the rainfall in Taiwan tends to cause zonal or seasonal drought very easily because of the unequal distribution in certain areas and during certain seasons. As a result of economic development, population growth and the increasing costs of exploiting new water sources (such as the building of dams), Taiwan's problem of water shortage will only go from bad to worse in the future (Taiwan Water Cooperation, 2014).

According to the Society for Wildlife and Nature in Taiwan, even though Taiwan has annual rainfalls reaches 2,500mm (i.e., 896 billionmetric ton), which is three times of the world average, but 480 billion metric ton flow into the ocean, 282 billion metric ton evaporated, and only 134 billion metric ton of surface water can be utilized. Annual amount of water percapita is only 4,500 metric ton, which is 1/7 of the world average. However, the annual amount of water usage is 190 billion metric ton which is higher than the limit. Thus, among the world's water shortage countries, Taiwan is ranked the 18th. In Taiwan, the amount of daily domestic water per person is around 270 liter, but except for 2 liter used for drinking, the rest is becoming daily waste water. At present, the waste water treatment in Taiwan is quite popular; still there are many households, institutions, and factories cause pollution for water sources consciously or unconsciously. Due to this situation, the Society for Wildlife and Nature suggests some methods to cherish and protect water resources as follows: to reduce water footprint, not to discharge daily waste water at one's pleases, do not discard expired drug at will,

recycle treatment to reduce pollution, not to play at the water source protected zone, participate the activity of planting trees on Arbor Day, cultivate the good habit of saving water, purchase green good, and be careful of those "greenwash" enterprises (Society for Wildlife and Nature, 2013).

In general, there are three water sources for tap-water supply in Taiwan: under-round water (wells), surface water (rivers and streams), and reservoirs. According to the *Yearbook of Environmental Protection Statistics, 2018*, the data of water quality of wells, rivers, and reservoirs related to six municipalities are listed respectively in Table 2, Table 3, and Table 4.

Regarding underground water, because there is no data specifically for six municipalities, Table 2 shows the percentage of wells below allowable concentration levels in 2017 in Taiwan. It is notable that on average, 92.8% of wells have measured values below allowable concentration levels.

Table 2

Percentage of Wells Below Allowable Concentration Levels, 2017

Year & quarter	Average	Indicative parameters								
		Total hardness	Total dissolved solids	Chloride	Ammonia nitrogen	Nitrate nitrogen	Sulfate	Total organic carbon	Phenols	Floirode
2017	92.8	92.5	90.5	93.6	59.9	100.0	96.0	99.5	99.6	100.0
1st Qur.	91.7	89.2	89.2	93.3	50.8	100.0	96.7	99.2	98.3	100.0
2nd Qur.	92.8	93.6	90.4	93.6	60.5	100.0	96.1	99.7	99.7	100.0
3rd Qur.	91.6	89.2	89.2	93.3	53.3	100.0	94.2	99.2	100.0	100.0
4th Qur.	93.3	93.5	91.4	93.7	63.7	100.0	96.2	99.5	99.8	100.0

Year & quarter	Heavy metals								
	Arsenic	Cadmium	Copper	Lead	Zinc	Mercury	Nickel	Iron	Manganese
2017	99.6	100.0	100.0	100.0	100.0	100.0	100.0	75.4	55.9
1st Qur.	99.2	100.0	100.0	100.0	100.0	100.0	100.0	70.8	55.8
2nd Qur.	99.7	100.0	100.0	100.0	100.0	100.0	100.0	73.3	56.3
3rd Qur.	99.2	100.0	100.0	100.0	100.0	100.0	100.0	70.8	52.5
4th Qur.	99.5	100.0	100.0	100.0	100.0	100.0	100.0	79.2	56.7

Source: *Yearbook of Environmental Protection Statistics, 2018* (環境保護統計年報107年), Table 3-8. Available at https://www.epa.gov.tw/Page/AB53FDCE3BDB3639?page=2&M=S.

Regarding the water quality of major rivers in six municipalities, the data of 2017 are listed in Table 3. It is notable that of 13 rivers, in terms of unpolluted length, the most polluted rivers are Laochieh Chi in Taoyuan City (22.7%) and Erhjen Chi in Kaohsiugn City (27.2%).

Table 3

Water Quality of Major Rivers in Six Municipalities

City	River	Length of river (km)	Polluted level (% of river length)				Annual average of inspections (unit: mg/L)			
			Unpolluted	Light polluted	Medium polluted	Heavy polluted	DO (溶氧量)	BOD_5 (生化需氧量)	SS (懸浮固體)	NH_3-N (氨氮)
Taipei and New Taipei	Tanshui River 淡水河系	323.4	71.6	9.8	15.0	3.5	6.8	2.4	18.5	1.07

Table 3 to be continued

Taoyuan	Nankan Chi南崁溪	30.7	--	1.7	69.9	28.4	6.3	12.3	26.7	6.12
	Laochieh Chi老街溪	37.1	22.7	23.0	49.9	4.4	7.7	7.8	21.6	2.47
Taichung	Shetzu Chi 社子溪	24.2	34.8	17.4	41.4	6.4	8.0	9.0	12.9	2.65
	Tachia Chi大甲溪	140.2	100.0	--	--	--	9.4	1.0	15.1	0.07
	Wu Chi烏溪	116.8	87.6	8.9	3.5	--	8.0	2.4	120.1	0.71
Tainan	Pachang Chi八掌溪	80.9	59.5	16.1	24.3	--	8.1	2.5	54.4	1.34
	Chishui Chi急水溪	65.2	46.4	8.4	29.7	15.5	3.6	6.4	43.7	3.64
	Tsengwen Chi曾文溪	138.5	80.2	17.2	2.7	--	7.5	1.3	411.1	0.20
	Yenshui Chi鹽水溪	41.3	46.4	6.3	35.5	11.8	5.3	4.3	174.5	4.11
Kaohsiung	Erhjen Chi二仁溪	65.2	27.2	11.8	41.2	19.8	5.3	8.0	244.2	10.47
	Akungdian Chi 阿公店溪	29.7	47.8	12.5	29.7	9.9	4.8	7.4	699.1	9.57
	Kaoping Chi 高屏溪	170.9	52.2	8.9	37.6	1.1	7.4	2.7	842.3	1.41

Source: *Yearbook of Environmental Protection Statistics,2018* (環境保護統計年報107年), Table 3-1 and Table 3-2.

Regarding the reservoir, there are 10 reservoirs providing water sourcesfor the tap-water in six municipalities. Table 4 shows the water quality of these reservoirs in terms of Carlson Trophic State Index (CTSI) estimated in 2017.

Table 4

Trophic State Index of Reservoirs Serving the Six Municipalities (2017)

Reservoir	CTSI	Served area
Feitsui 翡翠水庫	38 (low)	Taipei City and New Taipei City
Shiemen 石門水庫	48 (medium)	New Taipei City and Taoyuan City
Liyutan 鯉魚潭水庫	46 (medium)	Taichung City
Paiho 白河水庫	55 (high)	
Tzengwen 曾文水庫	47 (medium)	
Wushantou 烏山頭水庫	45 (medium)	Tainan City
Nanhua 南化水庫	45 (medium)	
Chingmien 鏡面水庫	51 (high)	
Akungdien 阿公店水庫	…	
Cheng-ching-hu 澄清湖水庫	54 (high)	Kaohsiung City
Fengshan 鳳山水庫	77 (high)	

Source: *Yearbook of Environmental Protection Statistics, 2018* (環境保統計年報107年), Table 3-3.

According to the definition given by the Environmental Protection Administration, the CTSI is classified in three categories: the low eutrophic level (貧養, CTSI<40), the medium eutrophic level (中養, CTSI=40-50), and high eutrophic level (優養, CTSI>50). Thus, Table 3 reveals that except for AkungdienReservoir (阿公店水庫) serving Kaohsiung City has no data; of the other ten reservoirs, only Feitsui Reservoir (翡翠水庫) serving Taipei City and New Taipei City is low eutrophic. While five reservoirs, Shimen (石門水庫), Liyutan (鯉魚潭水庫), Tzengwen (曾文水庫), Wushantou (烏山頭水庫), and Nanhua (南化水庫) serving Taoyuan, Taichung, and Tainan Cities are medium eutrophic, two reservoirs, Paiho (白河水庫) and Chingmien (鏡面水庫) serving Tainan City are high eutrophic; and two reservoirs, Cheng-ching-hu (澄清湖水庫) and Fengshan (鳳山水庫) serving Kaohsiung City are also high eutrophic.

The Tap-Water Supply for Six Municipalities

The tap-water supply for Taipei City is managed by the Taipei Water Department (TWD, 台北市自來水事業處), while that of other five municipalities is managed by Taiwan Water Cooperation (TWC, 台灣自來水公司). This section will discuss the situation tap-water supply for each municipality with available data at the end of 2017.

In Taipei City, the tap-water supply is managed by Taipei Water Department. Table 5 shows the source, served area, and volume of tap-water supply for Taipei City in 2017. Excluding three items without data, the total volume of water supply is 827,173,616 m^3/year, of which Zhitan Clean Water Source (直潭淨水廠) has the largest share of 74.24% (614,056,140 m^3/year), followed by 14.18% (117,288,342 m^3/year) of Clear Water Source No. 1 (長興淨水廠), 1.31% (10,814,773 m^3/year) of Clear Water Source No. 5 (陽明淨水廠), and 0.97% (8,004,130 m^3/year) of Clear Water Source No. 3 (雙溪淨水廠).

Table 5

The Source, Served Area, and Volume of Tap-Water of Taipei City in 2017

Items	Water source	Kind of water	Served area	Volume of water supply (m^3/year)
長興淨水廠 Clear Water Source No. 1	Clear water works of Mt. Toad	Surface water	Taipei Municipality, Zhonghe, Yonghe, and Sanchong	117,288,342
公館淨水廠 Clear Water Source No. 2	Clear water works of Xindian Stream	Surface water	Taipei Municipality, Zhonghe, Yonghe, and Sanchong	77,010,231
雙溪淨水廠 Clear Water Source No. 3	Water supply system of Yangming and Shuangxi	Spring and Atesian water	Shilin and Beitou area	8,004,130
南港淨水廠 Clear Water Source No. 4	Water supply system of Nangang and Neihu	Surface water	Neihu and Nangang area	--
陽明淨水廠 Clear Water Source No. 5	Water supply system of Shilin and Beitou	Spring and Atesian wate	Shilin and Beitou area	10,814,773
直潭淨水廠 Zhitan Clean Water Source	Zhitan source of Xindian Stream	Surface water	Taipei Area and nearby towns	614,056,140
十四張淨水廠 Shisizhang Clear Water Source	Clear water works of Xindian Stream	Underground water	Xindian	--
地下水源 Underground source	Underground source	Pump water	Taipei Area and nearby towns	--
配水總量 Total volume of water supply				827,173,616

Source: *Taipei City Statistical Yearbook 2017* (中華民國106年台北市統計年報), Table 154, http://w2.dbas.taipei.gov.tw/NEWS_WEEKLY/abstract/data/11/61540.htm (accessed on 2019/02/18).

In New Taipei City, the tap-water supply is managed by the First, the Second, and the 12th Branch Office of Taiwan Water Cooperation with eight systems as listed in Table 6. It should be noted that the Keelung System also supplied tap-water for Keelung City, and parts of Linkou District (林口區), Wuku District (五股區), Taishan District (泰山區), and Luchu District (蘆竹區) are supplied by the Shihmen System. The available figures show that except for Shihmen System, the total supply capacity is 1,614,600 m^3/day, of which the BanSin System has the largest share of 68.26% (1,102,200m^3/day).

In Taoyuan City, the tap-water supply is managed by the Second Branch Office of Taiwan Water Cooperation with two systems as shown in Table 7. It is notable that the total supply capacity is 1,461,300

m^3/day, of which 1,460,000 m^3/day (99.91%) is provided by Shihmen System, and the rest 1,300 m^3/day (0.09%) is provided by Fusing System. It should also be noted that at some remote places within Taoyuan City, tap-water supply has not yet available.

Table 6

The Source of Tap-Water in New Taipei City, 2017

Supply system	Water sources			Supply capacity (m^3/day)
	Underground	Surface	Reservoir	
The 1st Branch Office				
基隆Keelung System	萬里湧泉, 二坪湧泉	雙溪, 基隆河, 蛇形溪, 康誥坑溪, 東勢溪, 瑪鍊溪, 瑪陵坑溪	西勢水庫, 新山水庫	458,000
坪林Pinglin System		北勢溪, 景美溪, 無名溪, 東勢格溪, 烏塗溪		18,900
淡水Danshuei System	北投子湧泉, 湧泉, 三芝1, 2號井	公司田溪, 老梅溪, 四合興圳		25,500
金山Jinshan System		頂中股圳, 三重橋		8,000
烏來Wulai System		桶後溪		400
雙溪Shuangxi System				1,600
The 2nd Branch Office				
石門區Shihmen System			石門水庫 Shihmen Reservoir	
The 12th Branch Office				
板新區BanSin System	泰山第一水源(深井), 泰山第三水源(深井), 泰山第五水源(深井), 永和深井	三峽河	石門水庫(鳶山堰) Shihmen Reservoir (Yuanshan Dam)	1,102,200
Total supply capacity				1,614,600

Source: Taiwan Water Cooperation, *Taiwan Water Cooperation Statistical Yearbook, 2018* (台灣自來水公司統計年報107年), Table 1.

Table 7

The Source of Tap-Water in Taoyuan City, 2017

Supply system	Water sources			Supply capacity (m^3/day)
	Underground	Surface	Reservoir	
石門區 Shihmen System			石門水庫 Shihmen Reservoir	1,460,000
復興 Fusing System		觀音洞(山澗水), 詩朗溪		1,300
Total supply capacity				1,461,300

Source: Same as Table 6.

In Taichung City, the tap-water supply is managed by the Fourth Branch Office of Taiwan Water Cooperation with 10 systems as shown in Table 8. It is notable that underground water sources are quite widely used in Taichung City. And the served area of Jhuolan System also cover Jhuolan Township (卓蘭鎮) of Miaoli County (苗栗縣). The total supply capacity is 1,601,875 m^3/day, of which Taichung System has the largest share of 93.56% (1,497,748 m^3/day), followed by 1.87% (30,000 m^3/day) of Dongshih System, 1.39%

(22,200 m^3/day) of Dajia System, and 0.69% (11,000 m^3/day) of Sinshe System, while the rest of five systems all have supply capacity lower than 10,000 m^3/day.

In Tainan City, the tap-water supply is managed by the Sixth Branch Office of Taiwan Water Cooperation with two systems as listed in Table 9. Of the total supply capacity of 1,214,677 m^3/day, Tainan System has the lion share of 99.39% (1,207,321 m^3/day) and the NansiYujing System has the rest of 0.61% (7,356 m^3/day).

Table 8

The Source of Tap-Water in Taichung City, 2017

Supply system	Water sources			Supply capacity (m^3/day)
	Underground	Surface	Reservoir	
台中區Taichung System	有47口井(名單不細列)	大甲溪(石岡壩), 后里圳	鯉魚潭水庫	1,498,748
新社Sinshe System	馬力埔淺井, 苗圃深井, 新二村深井			11,000
谷關Guguan System		八仙山山泉水		27
霧峰Wufong System	舊正1號井, 舊正2號井, 坑口1, 3, 5, 6, 7號等五口井, 霧峰1, 2號等2口井			17,300
東勢Dongshih System	慶東2, 3, 4, 5, 6號井, 東勢淨水場1, 2號井	大甲溪		30,000
卓蘭Jhuolan System	卓蘭1, 2, 3, 4, 5, 內灣1, 2號井			7,500
梨山Lishan System		合歡溪		1,600
大肚Dadu System	大肚1, 2, 4, 5號井及台紙1, 2號等六口井, 福山1, 2, 3, 4號等四口井			9,300
大甲Dajia System	大甲第一水源等11口井, 頂店1,2號井, 大安淨水場1, 2號井, 日南淨水場1, 2, 5, 8, 11號井	溫寮溪		22,200
外埔Waipu System	外埔1號井, 7號井及9號井3口井			4,200
Total supply capacity				1,601,875

Source: Same as Table 6.

Table 9

The Source of Tap-Water in Tainan City, 2017

Supply system	Water sources			Supply capacity (m^3/day)
	Underground	Surface	Reservoir	
臺南區 Tainan System		曾文溪	曾文水庫, 烏山頭水庫聯合運用, 南化水庫, 白河水庫, 鏡面水庫	1,207,321
楠西玉井 NansiYujing System		劍文溪	曾文水庫, 烏山頭水庫聯合運用	7,356
Total supply capacity				1,214,677

Source: Same as Table 6.

In Kaohsiung City, the tap-water supply is managed by the Seventh Branch Office of Taiwan Water Cooperation with 12 systems as listed in Table 10. Of the total supply capacity of 1,795,930 m^3/day, Kaohsiung System has the largest share of 97.44% (1,750,000 m^3/day) followed by 1.34% (24,000 m^3/day) of Cishan System and 0.67% (12,000 m^3/day) of Meinong System, while the supply capacities of other nine systems are all rather small.

Table 10

The Source of Tap-Water in Kaohsiung City, 2017

Supply system	Water sources			Supply capacity (m^3/day)
	Underground	Surface	Reservoir	
高雄區Kaohsiung System		高屏溪, 會結站, 南化水庫	澄清湖水庫, 鳳山水庫, 阿公店水庫	1,750,000
旗山 Cishan System	手巾寮6口井			24,000
茂林 Maolin System	茂林2口井			500
美濃 Meinong System	美濃3口井, 廣興2口井			12,000
甲仙 Jiasian System		旗山溪		1,500
六龜 Liouguei System		荖濃溪		3,000
新威 Sinwei System		荖濃溪		1,400
木梓 Muzih System		旗山溪		1,000
寶隆 Baolong System				540
民生 Minsheng System		旗山溪支流		340
寶來 Baolai System		寶來溪		1,400
多納Duona System	多納1口井			250
Total supply capacity				1,795,930

Source: Same as Table 6.

The Tap-Water Quality

As for the quality of tap-water for six municipalities, the available data of raw water quality in 2018 at purification plants and water sources for the six municipalities are listed in Appendix Tables 1 to 6. It is notable that for Taipei City (Appendix Table 1), we can see that 15 items among 45 detected items are higher than the detected limits. These items are: chloride salt, sulfate, nitrate nitrogen, COD, total hardness, calcium, iron, manganese (except Shihlin and Yangmingshan 1st), coliform group, lead (only at Changxing), aluminum, arsenic (except Zhitan), chromium (only at Changxing and Shuangxi), zinc, selenium (except Shuangxi and Yangmingshan 1st). Furthermore, Appendix Tables 3 to 7 show that the detected items are all 65 for New Taipei City, Taoyuan City, Taichung City, Tainan City, and Kaohsiung City. The values of these 65 items are all lower than the detected limit.

It should be noted that even though Taipei City has 15 items with detected values higher than the detected limits, Appendix Table 7 reveals that they are still lower than the drinking water regulations of Taiwan, the United States of America, Japan, the European Union, and the World Health Organization.

The Tap-Water Supply Pervasion Rate

This section will discuss the tap-water supply pervasion rate with a comparative perspective. In Taipei City, there is no data of the tap-water supply provision rate in each district; however, there are data of water consumption per person per day and per household per day during 2008-2017. As for the other five municipalities, the tap-water supply pervasion rate in each district is available in the *Statistical Yearbook of Taiwan Water Cooperation*. The tap-water supply pervasion rates at the end of 2017 in the five municipalities are shown with figures.

Taipei City

The tap-water pervasion rate in Taipei City is 99.62% in 2017. Figure 1 shows the division of districts and the pervasion rates in 2008-2017 are listed in the Table 11.

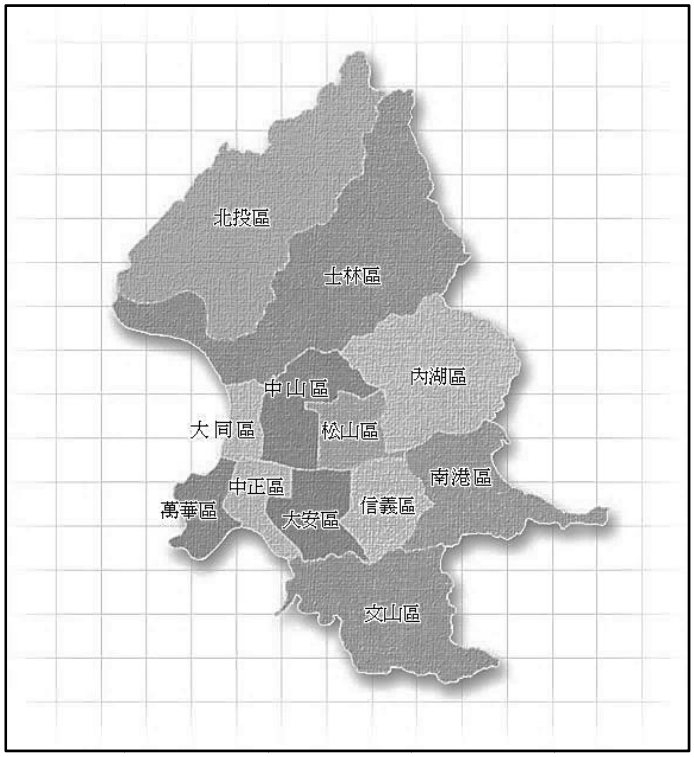

Figure 1. The division of districts in Taipei City.

Table 11

Tap-Water Supply Pervasion Rate and Water Consumption per Day in Taipei City

Year	Domestic water consumption (per person per day/liter)	Domestic water consumption (per household per day/liter)	Water supply pervasion rate (%)
2008	331	243	99.51
2009	332	227	99.51
2010	331	225	99.54
2011	329	222	99.55
2012	326	220	99.60
2013	326	220	99.60
2014	327	219	99.60
2015	326	218	99.60
2016	326	218	99.62
2017	327	219	99.62

Source: The map is obtained from Taipei City Government, https://www.gov.taipei/cp.aspx?n=1F076481DD9E556B(accessed on 2019/01/18). The tap-water supply pervasion rate is from Taipei Water Department (台北市自來水事業處), https://www.water.gov.taipei/cp.aspx?n=672BBBC689F026CA(accessed on 2019/01/30).

New Taipei City

The average pervasion rate of tap-water supply in New Taipei City is 96.98% in 2017. Figure 2 shows the division of district in New Taipei City, and the tap-water supply pervasion rates in 27 districts are listed in the Table 12.

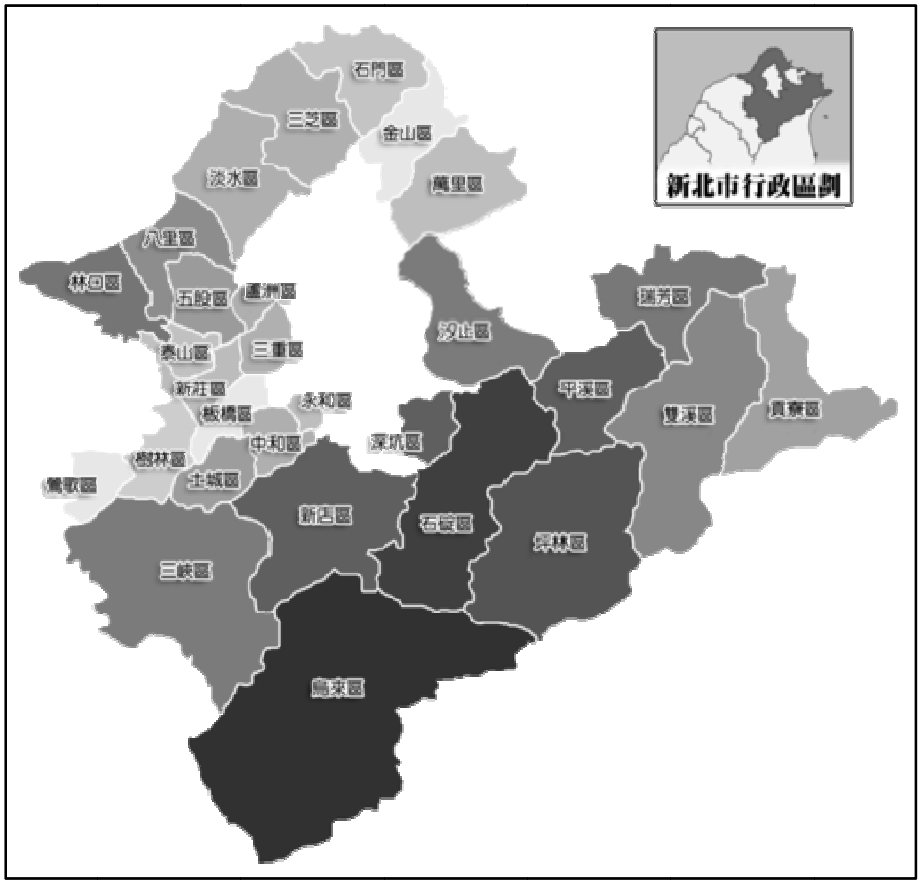

Figure 2. Division of districts in New Taipei City.

Table 12

The Tap-Water Pervasion Rate of Each District in New Taipei City, 2017

District	%	District	%	Dsitrict	%
板橋區 Banchiao	99.15	瑞芳區 Juifang	91.86	三芝區 Sanchih	92.66
三重區 Sanchong	98.83	土城區 Tucheng	99.56	石門區 Shimen	30.18
中和區 Chunghe	99.35	蘆洲區 Luzhou	98.61	八里區 Pali	97.93
新莊區 Xinzhuang	98.79	五股區 Wugu	99.93	平溪區 Pingxi	46.69
樹林區 Shulin	99.06	泰山區 Taishan	99.84	雙溪區 Shuangxi	39.18
鶯歌區 Yingge	98.02	林口區 Linkou	92.39	貢寮區 Gongliao	60.88
三峽區 Sanxia	99.69	深坑區Shenkeng	98.04	金山區 Jinshan	78.98
淡水區 Danshui	99.15	石碇區 Shihding	29.01	萬里區 Wanli	80.84
汐止區Shijih	98.89	坪林區 Pinglin	15.91	烏來區 Wulai	19.49

Source: The map is obtained from the website: https://zh.wikipedia.org/wiki/file: New_Taipei_map.png (accessed on 2019/02/21). For the tap-water pervasion rate, see *Statistical Yearbook of Taiwan Water Cooperation, 2018*, Table 7.

Taoyuan City

The average pervasion rate of tap-water in Taoyuan City is 95.44% in 2017. Figure 3 shows the division of districts in Taoyuan City and the tap-water pervasion rates in 13 districts are listed in the Table 13.

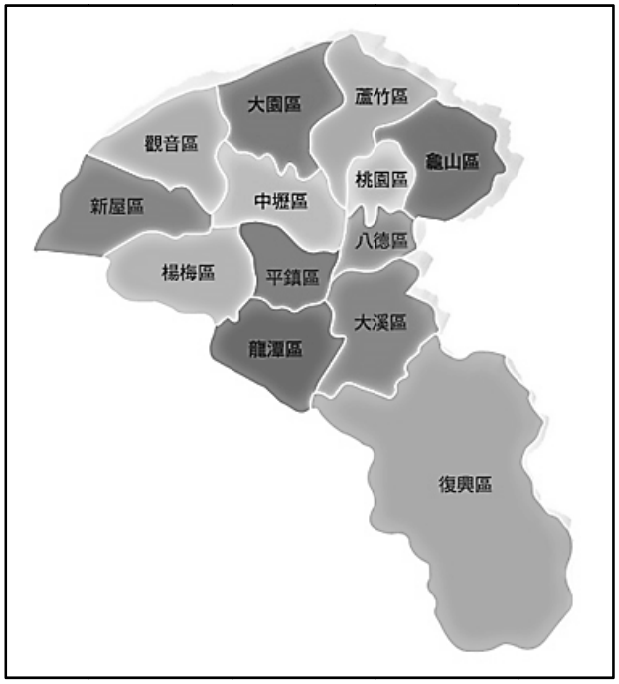

Figure 3. Division of districts in Taoyuan City.

Table 13

Tap-Water Pervasion Rate of Districts in Taoyuan City, 2017

District	%	District	%	District	%
桃園區 Taoyuan	97.69	大溪區 Tachi	87.71	龍潭區 Longtan	91.25
中壢區 Chungli	99.41	蘆竹區 Luchu	98.92	新屋區 Hsinwu	93.59
平鎮區 Pingchen	96.72	大園區 Tayuan	88.87	觀音區 Kuanyin	86.04
八德區 Bade	99.00	龜山區 Kuaishan	97.24	復興區 Fuxing	20.02
楊梅區 Yangmei	89.41				

Source: The map is taken from Taoyuan City Government website: https://www.tycg.gov.tw/ch/home.jsp?id=59&parentpath=0,6,58. The data of tap-water supply pervasion rate is from *2018 Statistic Yearbook of Taiwan Water Cooperation*, Table 7.

Taichung City

The average tap-water pervasion rate of Taichung city in 2017 is 95.63%. Figure 4 shows the division of districts and the tap-water pervasion rates in 29 districts are listed in the Table 14.

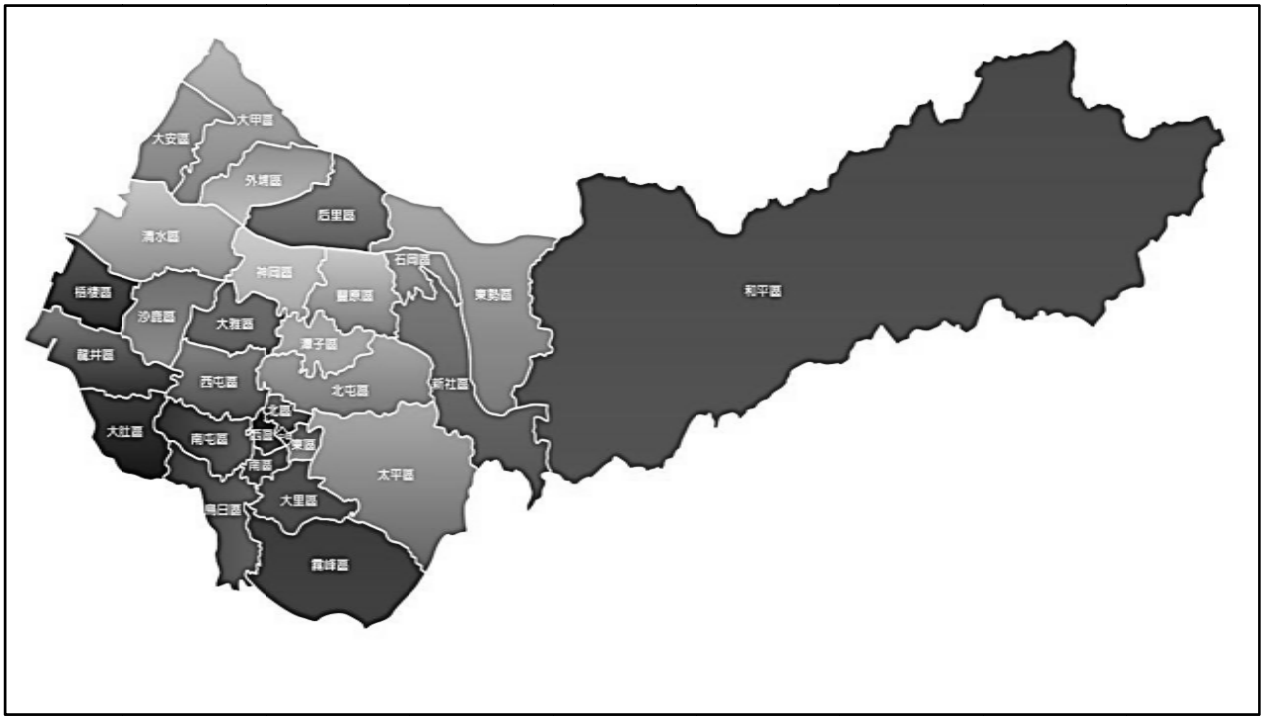

Figure 4. Division of districts in Taichung City.

Table 14

Tap-Water Supply Pervasion Rate in 29 Districts of Taichung City, 2017

District	%	District	%	District	%
中區Middle	99.84	大甲區 Tachia	88.62	外埔區 Waipu	90.12
東區East	99.33	清水區 Chingshui	74.17	大安區Da'an	62.92
南區South	99.98	沙鹿區 Shalu	98.19	烏日區 Wuji	96.23
西區West	99.94	梧棲區 Wuchi	98.52	大肚區 Tatu	97.91
北區North	99.94	后里區 Houli	99.89	龍井區 Longjing	98.03
西屯區 Xitun	99.54	神岡區 Shengkang	99.32	霧峰區 Wufeng	80.88
南屯區 Nantun	99.97	潭子區 Tantsu	99.03	太平區 Taiping	95.69
北屯區 Paitun	99.97	大雅區 Taya	97.34	大里區 Tali	94.27
豐原區 Fengyuan	99.27	新社區Xinshe	73.52	和平區 Hoping	10.20
東勢區 Tongshi	80.78	石岡區 Shihgang	62.67		

Source: The map is obtained from the Taichung City Government website, https://www.taichung.gov.tw/8868/9945/10014/676413/post. The data of tap-water supply pervasion rate is from *2018 Statistic Yearbook of Taiwan Water Cooperation*, Table 7.

Tainan City

The average pervasion rate of tap-water in Tainan City is 99.06% in 2017. Figure 5 shows the division of districts in Tainan City and the tap-water pervasion rates of 37 districts are listed in the Table 15.

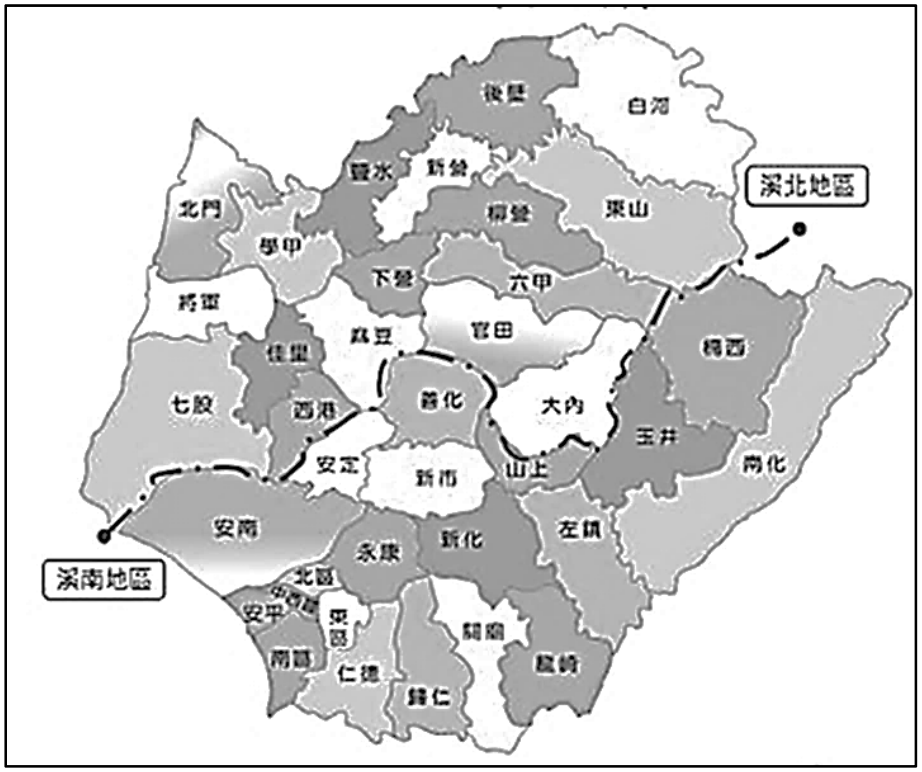

Figure 5. Division of districts in Tainan City.

Table 15

Tap-Water Supply Pervasion Rate in Tainan City, 2017

District	%	District	%	District	%	District	%
新營區Xinying	99.99	大內區 Danei	86.34	安定區 Anding	99.80	永康區 Yongkang	99.48
鹽水區Yenshui	99.15	佳里區 Jiali	98.85	山上區 Shanshang	98.37	東區 East	99.88
白河區Baiho	96.00	學甲區 Xuechia	97.52	玉井區 Yujing	99.80	南區 South	99.88
柳營區Liuying	95.26	西港區 Xigang	98.04	楠西區 Nanxi	99.94	北區 North	99.88
後壁區Houbi	97.25	七股區 Chiku	96.50	南化區 Nanhua	93.41	安南區 Annan	99.88
東山區Dongshan	83.23	將軍區 JIangchun	97.09	左鎮區 Zhuozeng	99.34	安平區Anping	99.88
麻豆區Madou	99.18	北門區 Beimen	96.00	仁德區 Jende	99.96	中西區 Chungxi	99.88
下營區Xiaying	97.60	新化區 Xinhua	99.86	歸仁區 Kuijen	99.94		
六甲區Liuchia	99.53	善化區 Shanhua	99.96	關廟區 Kuanmiao	98.16		
官田區Kuantien	99.01	新市區 Xinshi	99.96	龍崎區 Longchi	75.16		

Source: The map is obtained from Tainan City Government website, https://www.tainan.gov.tw/cp.aspx?n=13292. The tap-water supply provision rate is from *2018 Statistic Yearbook of Taiwan Water Cooperation*, Table 7.

Kaohsiung City

The average tap-water pervasion rate of Kaohsiung City is 95.81% in 2017. Figure 6 shows the division of districts in Kaohsiung City and the pervasion rates in 35 districted are listed in the Table 16.

Figure 6. Divisions of districts in Kaohsiung City.

Table 16

Tap-Water Pervasion Rates of 35 Districts in Kaohsiung City, 2017

District	%	District	%	District	%	District	%
鹽埕區 Yencheng	99.52	小港區 Xiaogang	99.73	燕巢區 Yentsao	96.00	美濃區 Meinong	60.60
鼓山區 Kushan	99.75	鳳山區 Fengshan	99.07	田寮區 Tianliao	92.98	六龜區 Liukuai	68.83
左營區 Zuoying	99.59	林園區 Linyuan	88.79	阿蓮區Alian	92.64	甲仙區 Jiachien	71.85
楠梓區 Nantse	94.97	大寮區 Daliao	86.58	路竹區 Luzhu	98.54	杉林區 Shanlin	48.48
三民區 Sanming	99.72	大樹區 Dashu	60.98	湖內區 Hunei	93.24	內門區 Neimeng	83.84
新興區 Xinxing	99.73	大社區 Dashe	98.97	茄萣區Chiehding	88.09	茂林區 Maolin	49.89
前金區 Chienjin	99.75	仁武區Jenwu	99.88	永安區 Yongan	84.24	桃源區 Taoyuna	15.19
苓雅區 Lingya	99.67	鳥松區 Niaosong	90.54	彌陀區 Mituo	96.36	那瑪夏區Namaxia	14.92
前鎮區Chinecheng	99.75	岡山區 Gangshan	99.01	梓官區Ziguan	96.91		

Source: The map is obtained from Kaohsiung City Government, https://www.kcg.gov.tw/cp.aspx?n=07880B28C8E3EAEA (accessed on 2019/02/21). The tap-water supply provision rate is from *2018 Statistic Yearbook of Taiwan Water Cooperation*, Table 7.

From the above maps and the data of tap-water provision rates in 2017, notable points for each municipality are as follows:

(1) In Taipei City, the average pervasion rate since 2008 was around 99.5% and in 2017 it reached 99.98%, the highest rate among six municipalities.

(2) In New Taipei City, the average pervasion rate in 2017 is 96.98%, but there are five districts with pervasion rate below 50%; they are PingxiDistrict (平溪區) 46.69%, Shuanxi Dsitrict (雙溪區) 39.18%, Shihmen Dsitrict (石門區) 30.18%, Wulai District (烏來區) 19.49%, and Pinglin District (坪林區) 15.91%.

(3) In Taoyuan City, the average pervasion rate in 2017 is 95.44%, but Fuxing District (復興區) only has 20.02%.

(4) In Taichung City, the average pervasion rate in 2017 is 95.63%, but Hoping District (和平區) only has 10.20% and other four districts have pervasion rate below 80%; they are: Shihgang District (石岡區) 62.67%, Da'an District (大安區) 62.92%, Xinshe District (新社區) 73.52%, and Chingshui District (清水區) 74.17%.

(5) In Tainan City, the average pervasion rate in 2017 is 99.06%, next only to Taipei City, but LongchiDistrict (龍崎區) only has 75.16%.

(6) In Kaohsiung City, the average pervasion rate in 2017 is 95.81%, but four districts have the pervasion rate below 50%; they are: NamaxiaDistrict (那瑪夏區) 14.90%, Taoyuan District (桃源區) 15.19%, Shanlin District (杉林區) 48.48%, and Maolin District (茂林區) 49.89%.

In other words, currently, the average tap-water pervasion rates in six municipalities are all above 95%, but the distribution among districts are rather uneven. This is mostly due to the geographic conditions of the remote districts where pervasion rates are very low.

Some Notable Events of Water Pollution and Remediationin Recent Years

In below, some notable events of water pollution in recent years regarding water sources for each municipality will be presented.

On March 29, 2017, Dr. Chien-Hsin Lai (賴建信), Director-General of Water Resources Agency delivered a speech at the Taipei Forum of Water Environment (台北水環境論壇). He mentioned the crisis of water supply in Taiwan in 2017 and pointed out Taiwan should develop recycled water and its peripheral benefit in order to solve the problem of lacking water and to develop industry. He said that the goal is to utilize 1,320,000 tons of recycled water per day in 2031 (Huang, 2017).

Also at the Taipei Forum of Water Environment held on March 29, 2017, Vice Minister of the Interior, Lin Ci-ling (林慈玲) pointed out that Ministry of Interior planned to develop recycled water at six locations over Taiwan and expected to increase 280,000 metric ton of recycled water per day for industrial use and to save the water for daily use of 1,200,000 people. But, it is notable that Deputy Director of Construction and Planning Agency Ministry of The Interior, Yu Wang-shen (於望聖) said that the average water price in Taiwan is about NT 10 dollar; thus it is difficult to attract the business firms to use recycled water, but the goal of the government is to let the industry to use recycled water and save the water for daily use of common people. Furthermore, Professor Lin Kuo-feng (林國峰) of Department of Civil Engineering, National Taiwan University, reminds that providing the recycled water for industry could only be used in cooling, and if used in the manufacturing process, it is necessary to fulfill certain standard (Huang& Yang, 2017).

On August 30-September 1, 2018, the 2018 International Forum of Water Environment and Exhibition (2018年台北國際水環境高峰論壇及產業展覽) was held in Taipei City. The purpose of this forum and exhibition is to promote communication of urban water environment policy, technology upgrade, and industrial development. More than 500 participants were invited from Indonesia, Malaysia, Philippine, Vietnam, Laos, Myanmar, Thailand, Korea, Singapore, Japan, Cambodia, the Netherland, the USA, United Kingdom, South Africa, China. The themes of exhibition are as follows:

(1) Smart Water Management (smart disaster prevention, pumping station automation, smart water network, open data, communication standard);

(2) Green Infrastructure (urban watershed countermeasures, public facilities water and water permeable design; garden city; green roof, Park and river creek ecological);

(3) Circular Economy (circulation and renewable of water resources, rainwater storage for reuse, reuse of by-products of waste water treatment, and related issues of environment protection);

(4) Water Treatment (diversification of waste water treatment, clean water system, sound water supply system, sea water and fresh water purification).[5]

A report on August 15, 2018 said that the day before there were more than 10,000 dead fishes at water shore of Danshuei River around Dadaocheng (大稻埕) in Taipei City. The Environmental Protection Bureau of Taipei City said that the species of these dead fishes is Eastern keelback mullet (烏仔魚). The cause of these dead fishes is due to the high temperature and low dissolved oxygen. Up to August 14, more than 35 metric ton of dead fish were got out of the water. The Environmental Protection Bureau pointed out that Taipei City and New Taipei city will work together to speed up cleaning in order to prevent affect the music festival to be hold season in this week (Chou, 2018).

In Taoyuan City, the Nankan Chi (南崁溪) has a population of 550,000 persons living along the river valley, a large amount of waste water from households and factories has caused serious river water pollution. The Laochieh Chi (老街溪) has Dayuan Industrial Zone (大園工業區) on its northern bank and thus industrial waste water caused serious river water pollution. The Datun Chi (大堀溪) has factories scattered on both sides of river and the waste water has affected the normal ecological function of this river (Environmental Protection Bureau of Taoyuan City Government, n.d.).

The two major rivers in Taoyuan City are Nankan Chi and Laochieh Chi; they have been polluted by daily waste water and by heavy metals from industrial waste water for a long time. The prevailing rate of waste water sewage in Taoyuan was only about 5% before Taoyuan became a municipality, but at the end of 2017, the rate has reached 12.4%. The four rivers in Taoyuan most heavily polluted by industrial waste water are Xinchieh Chi (新街溪), Puxin Chi (埔心溪), Laochieh Chi, and Nankan Chi. And the rivers polluted by industrial waste water also affected the soil of farmlands. According to the statistics of Environment Protection Bureau of Taoyuan City, there are 336 hectares of farmlands under pollution inspection and from 2003 to 2016 the government has spent NTD 7.4 billion to control the pollution, and it is expected that by the end of April 2017, around 190 hectares will be improved and deleted from the list of inspection (TVBSNews, n.d.).

In order to control the serious cooper pollution of farmlands along Nankan Chi (南崁溪), the Taoyuan City Government decided to control of limited amount of copper from January 7, 2018. The first grade control area is not allowed to establish new factories which release waste water containing cooper and the second grade control area is to change the emission standard from 3 mg/L to 1.2 mg/L. The first grade control area is located at the Tungmen Chi (東門溪) basin with a total area of 20,000 hectare. There are 190 factories, of which 121 factories have an allowing amount of cooper of 253.5 g/day, others include 43 factory of metal surface treatment industry and eight factories of electroplating industry. As for other factories to be controlled along Nankan Chi, the Environmental Protection Bureau pushed forward the "Autonomous reduction" plan and required those factories with daily cooper waste water more than 200 m^3 to reduce half of the amount, and there

[5] See http://www.taipeiwater2018.com/#(accessed on 2019/03/04).

are 62 factories belong to this category of which 34 factories have been approved to adopt the plan. And for factories which emit cooper waste water more than 1,000 m^3, it is necessary for them to equip the automatic monitoring system for release water quality and water volume within one year (Wei, 2018).

In Taichung City, in 2009 (before the municipality was formed), the results of river water pollution inspection revealed that the four major rivers, Luchuan (綠川), Liuchuan (柳川), Meichuan (梅川), and Mayuantouchi (麻園頭溪), were all listed as heavy pollution. Some city legislators urged the City Government to push forward the improvement measures, but the Environmental Protection Bureau contended that the origins of pollution were mostly from industrial waste water of Taichung County. The problem could be more easily solved if the city and the county were combined, but at present, it was only possible to communicate with Taichung County to strengthen the control (Tang & Su, 2009).

On September 17, 2010, Professor Chang Chengnan (張鎮南) of Tunghai University delivered a speech regarding the river pollution in Taichung Area. He mentioned that among rivers in Taichung City, Han Chi (旱溪) and Fatze Chi (筏子溪) are polluted in light to medium levels; Luchuan, Liuchuan, and Meichuan are polluted in heavy level. More than 90% of the pollution sources are from daily waste water. In Taichung County, the major rivers are Tachia Chi (大甲溪), Wu Chi (烏溪), and Da'an Chi (大安溪), and they were the focal points of pollution control. In recent years, the pollution conditions of these rivers in Taichung County had been improved mostly due to correct measures of control. Chang Chengnan suggested that Taichung area can learn from three examples regarding river pollution control. The first example is the control of Danshui River (淡水河) a decade ago with the result of creating a green belt along the river. The second example is the control of Ai River (愛河) in Kaohsiung City through the construction of waste water swages (the pervasion rate increased from 3.91% in 1997 to 50.17% in 2007) which make Ai River become a blue belt for Kaohsiung City. The third example is control of the Chingchichuan (清溪川Cheong-gyecheon) in Seoul, Korea, since 2003 with a result of international well known case. In sum, Chang Chengnan expected that Taichung could create continuous green belt and blue belt as soon as possible (Homemakers United Foundation (主婦聯盟環境保護基金會), Taichung Branch, Wang, 2010).

The World Water Monitoring Day (WWMD, 世界水質監測日) is a global activity concerning the quality of water environment. In 2003, America's Clean Water Foundation, ACWF (美國清水基金會) and USEPA (美國環保署) initiated and set September 18 of each year for this activity. In 2010, Tainan City gathered 500 persons, including students and teachers of primary and middle schools, and the member of River Inspection Team (河川巡守隊) to participate in the activity of the WWMD. They tried to design a mechanism for the public to participate in river conservation and examine the system for reporting pollution condition in order to reach the effect of pollution reduction (Water Environment Patrol Strategy Alliance, n.d.).

In Tainan City, the River Pollution Remediation Committee (河川污染整治委員會) was established on May 16, 2011. The focus is to control four major rivers, Erjen Chi (二仁溪), Yenshui Chi (鹽水溪), Jiangchun Chi (將軍溪), and Chishui Chi (急水溪), and to reach the goal of no lack of oxygen, no smell, and to revitalize the river banks (Chu, n.d.).

In 2017, the Executive Yuan put forward the forward-looking plan, in which the budget for projects concerning water environment reached NTD 2,500 billion. Thus, the Taijiang Culture Promotion Association (台江文化促進會) and other social organization along the Taijiang valley urged that the water environment projects should focus on the public governance of local rivers and invite local communities to participate in

discussions, and the Water Resource Agency (水利署) and Tainan City government should actually solve the problem of industrial waste water pollution in Jianan Irrigation Canal (嘉南大圳), in order to return no polluted water for coming generations and only this can be real forward-looking (Tsai, 2017).

According to a report in February 2018, the three major rivers in Tainan City—Erjen Chi (二仁溪), Chishui Chi (急水溪), and Yenshui Chi (鹽水溪)—were heavily polluted in 2017 with an increase of polluted length for 14 km. According to the Environment Protection Bureau, the cause of this pollution situation was due to little rainfalls in 2017. The polluted length in 2017 was 21.7 km (33.3%) in the Erjen Chi, 11.1 km (17%) in the Chishui Chi, and 6.1 km (14.7%) in the Yenshui Chi. Compared with 2016, the increased length pollution of Erjen Chi was 11.7%, the Yenshui Chiwas 10.3%, and the Chishui Chi was 3.2%. In addition to the above three rivers, there is the Jianchun Chi Drainage (將軍溪排水) with a length of 18.2 km, of which 15.6 km (64.4%) was heavily polluted, which indicated the situation of pollution was even more serious than the three rivers. The Tainan City Government contended that Tainan will emphasis the construction of swages, control the source of pollution, put forward the purification of water, and convert the livestock waste water (畜牧廢水) into energy. And the Government will also set the medium- and long-term goals and hope to reach the goal of no river pollution in 2021 (Tsai, 2018).

On January 20, 2019, The Tainan City Government reports that due to efforts of river remediation, the length of polluted rivers length has decreased 143.8 km; the water quality of rivers is the best in 10 years. The rivers under pollution control included Erjen Chi, Yenshui Chi, Jiangchun Chi, Chishui Chi, Tsengwen Chi, and Pachang Chi. As the prevailing rate of swage has been increasing, the amount of daily waste water flow has decreased and animal waste water has reduced through related equipment and reutilization. The Environmental Protection Bureau reported that up to the end of 2018, the length of polluted rivers has reduced 143.8 km, and it is estimated that by the year 2023, except for Jiangchun Chi, other rivers will reach the goal of no smell and no heavy polluted; and the total length of river control will be 178.4 km (Chang, n.d.).

In 2017, the Environment Protection Bureau of Kaohsiung City detected again in the late afternoon on December 8, that the Yukeng Pickling Factory (耕譽酸洗廠) located at the upstream of Fengshan Chi (鳳山溪) discharged untreated waste water with a pH value reached 0.99. According to the rule of *Water Pollution Control Act* (水污染防治法) and *Trash Clearance Act* (廢棄物清理法), the factory will be punished with at least NTD one million and urged to stop operation. The Environment Protection Bureau pointed out that the 0.99 pH acid liquid is a harmful industrial waste which can be harmful to human health and the river ecology, and through the irrigation ditches, it can caused heavy metal pollution of farming land (Tsai, 2017).

In December 2017, in Kaohsiung City, Fengshan Chi became blackening and smelly; the Environmental Protection Bureau and the River Inspection Team of Beimen District (北門里河川巡守隊) cooperated to seize three firms which discharge waste water illegally. At the upstream of Fengshan Chi, there are more than one hundred factories, including plating, pickling, and others. The River Inspection Team patrols every day to protect the river. On December 20, they discovered an illegal factory, Dafu (大福), which discharged a daily total volume of 31.8 tons of slurry water and waste water into the drainage and then into Fengshan Chi. After being reported, the factory was order to shut down and could be punished with NTD 60,000 to 20,000,000 (Chen, 2017).

In early 2019, it is reported that due to a lack of rainfalls since September of 2018, the flow of Kaoping Chi (高屏溪) is closing to the warning value (警戒值). Because there is no large reservoir in Kaohsiung City, the water for daily life (ca. 1,100,000 tons) is depended on the flow of Kaoping Chi. On January 28, 2019, the

Water Resource Bureau (水利局) opened five waste water treatment plants to provide 35,000 tons of effluent, in order to provide water for preventing dust at construction sites, and also asked the Irrigation Association (農田水利會) and Taiwan Sugar Company to provide 150 wells (which can provide about 10% of the total water demand for the city) for preventing the drought. And the Seventh Office of the Taiwan Water Cooperation urged the people to save water usages (Chen, 2019).

It is notable that the first Reclaimed Water Plant (再生水廠) along Fengchan Chi was completed and started operation in September 2018. This plant can supply daily 25,000 tons of water to Waterfront Industrial Area (臨海工業區). Due to the fact that conductivity of reclaimed water is only 25-26 EC (1 EC = 1μS/cm), the quality is far better than tap-water. It is expected that when the expansion is completed in August 2019, the daily supply capacity will reach 45,000 tons, which is equal to 20% of water demand of Waterfront Industrial Area. This Reclaimed Water Plant is constructed by the BOT (build-operate-transfer) pattern, and the park area is built with an image of blue whale with tourist factory, water technology, science education center, and open for the public to visit and outdoor teaching. The Water Resource Bureau is trying to hasten the second reclaimed water plant at Waterfront Industrial Area and to complete it in 2020. Together the two reclaimed water plants will have a daily capacity of 100,000 tons, which will be 40% of the water demand of Waterfront Industrial Area (Chen, 2018).

Concluding Remarks

With the global consensus of "access to clean water is a human right" as a background, this paper tries to discuss clean water supply and related issues at six municipalities in Taiwan in recent years. The findings are summarized in below.

(1) The population of six municipalities together makes up 69.3% of the total population of Taiwan Area in 2018.

(2) There are three water sources for tap-water supply in Taiwan: underground water (wells), surface water (rivers and streams), and reservoirs. The data in 2017 showed that 92.8% of wells had measured values below allowable concentration levels; of 13 rivers, the unpolluted length of Laochieh Chi in Taoyuan City is 22.7%, and Erhjen Chi in Kaohsiugn City is 27.2%; of the 10 reservoirs with available data, only Feitsui Reservoir serving Taipei City and New Taipei City is low eutrophic.

(3) The quality of tap-water for six municipalities with detected items in 2018 is all lower than the drinking water regulations of Taiwan, the United States of America, Japan, the European Union, and the World Health Organization.

(4) The data of tap-water pervasion rate in 2017 revealed Taipei City is 99.62%, New Taipei City is 96.98%, Taoyuan City is 95.44%, Taichung City is 95.63%, Tainan City is 99.06%, and Kaohsiung City is 95.81%. Yet, among districts the distribution are rather uneven. This is mostly due to the geographic conditions of the remote districts where pervasion rates are very low.

(5) It should be noted that in recent years, there were still some events of river pollution occurred, and the government environmental protection agencies and local communities have tried to work together to control the situation. Also, it is notable that the first reclaimed water plant started operation in September 2018 to supply water for industries and this helps to save tap-water for common use.

(6) As water environment is a complicated topic for study, it is hope that more research will be done in the future.

References

Chang, R. H. (張榮祥) (n.d.). River ramidication in Tainan reached more than 100 km in ten years (台南河川整治, 十年逾百公里). *Epoch Times* (大紀元). Retrieved from http://www.epochtimes.com/b5/13/1/20/n3781178.htm (accessed on 2019/02/27)

Chen, W. C. (陳文嬋) (2017). Fengshan Chi is black with bad smell, the Environmental Protection Bureau caught 3 businesses which discharge illegally (鳳山溪黑又臭, 高雄環局2週揪3業者偷排). *Liberty Times* (自由時報), 2017-12-21. Retrieved from http://news.ltn.com.tw/news/local/paper/1161966 (accessed on 2019/03/04)

Chen, W. C. (陳文嬋) (2018). The Fenshan Chi Reclaimed Water Plant is completed, this is the first one in Taiwan (全國首座,鳳山溪再生水廠完工). *Liberty Times* (自由時報), 2018-09-06. Retrieved from http://news.ltn.com.tw/news/local/paper/1230058 (accessed on 2019/03/04)

Chen, W. C. (陳文嬋) (2019). The water condition in Kaohsiung is not good, the waste water treatment plant open the effluent for use (高雄水情不佳, 污水處理廠放流水開放取用). *Liberty Times* (自由時報), 2019-01-29. Retrieved from http://news.ltn.com.tw/news/local/paper/1,264758 (accessed on 2019/01/29)

Chou, Y. Y. (周彥妤) (2018). Water shore of Dadaocheng in Taipei appears more than 10,000 dead fish (大稻埕水岸邊出現上萬條死魚). *Liberty Times* (自由時報), 2018-08-15. Retrieved from http://news.ltn.com.tw/news/local/paper/1224523 (accessed on 2019/03/04)

Chu, L. L. (朱莉利) (n.d.). The Committee for Remediation of Rivers in Tainan City is established (府城推動河川污染整治委員會成立). *Epoch Times* (大紀元). Retrieved from http://www.epochtimes.com/b5/11/5/16/n3258723.htm (accessed on 2019/02/27)

Environmental Protection Bureau of Taoyuan City Government. (n.d.). Introduction of rivers in Taoyuan City (桃園市河川水系介紹). Retrieved from http://web.tydep.gov.tw/08ACC/statistics/p1.html (accessed on 2019/02/27)

Homemakers United Foundation (主婦聯盟環境保護基金會), Taichung Branch, Wang, H.-Y. (王秀瑛) (2010). Remediation of rivers, possible in Seoul, impossible in Taichung (整治河川,首爾能, 台中不能). *Abstract of Lecture* (演講摘要), 2010-12-01. Retrieved from https://www.huf.org.tw/essay/content/624 (accessed on 2019/02/27)

Huang, C. H. (黃建豪), & Yang, M. C. (楊綿傑) (2017). To develop water resources, six reclaimed water plants will be built in Taiwan (開發水資源,全台將設六個再生水廠). *Liberty Times* (自由時報), 2017-03-30. Retrieved from http://news.ltn.com.tw/news/life/paper/1090067 (accessed on 2019/03/04)

Huang, Y. H. (黃意涵) (2017). Solve water shortage, water resources agency: Develop recycled water (解水荒,水利署: 發展再生水). *China Times* (中國時報), 2017-03-30. Retrieved from http://www.chinatimes.com/newspapers/20170330000649-260107 (accessed on 2017/03/30)

Society for Wildlife and Nature (中華民國自生態保育協會). (2013). Protect water resources (保護水資源). Retrieved from http://www.swan.org.tw/activity/2013/biodiversity/protect.html (accessed on 2015/12/28)

Taiwan Water Cooperation. (2014-02-25). Water sources. Retrieved from https://www.water.gov.tw/ct.aspx?xItem=2706&CtNode=883&mp=en (accessed on 2019/02/11)

Tang, T. H. (唐在馨), & Su, J. F. (蘇金鳳) (2009-07-27). Four major rivers in Middle Taiwan are heavily polluted, the Environmental Protection Bureau said that the origin is from Taichung County (中部4大河川嚴重污染, 環局: 源自中縣). Retrieved from https://news.ltn.com.tw/news/local/paper/322005 (accessed on 2019/02/27)

Tsai, C. H. (蔡清華) (2017). Strong acid waste water poured into Fengshan Chi, the factory was ordered to shutdown (強酸廢水排鳳山溪, 工廠勒令停工). *Liberty Times* (自由時報), 2017-12-10. Retrieved from http://news.ltn.com.tw/news/local/paper/1158941 (accessed on 2017/12/10)

Tsai, W. C. (蔡文居) (2017). Control waste water pollution of Taijiang, the City Government has a prospect (整治台江廢水污染, 市府: 已列前瞻). *Liberty Times* (自由時報), 2017-05-19. Retrieved from http://news.ltn.com.tw/news/local/paper/1103654 (accessed on 2019/03/04)

Tsai, W. C. (蔡文居) (2018). Three rivers in Tainan increased 14 km of heavy polluted last year (台南3污染河川重症段去年增14公里). *Liberty Times* (自由時報), 2018-02-06. Retrieved from http://news.ltn.com.tw/news/local/paper/1174982 (accessed on 2018/02/06)

TVBSNews. (n.d.). Heavy metal polluted rivers in Taoyuan City, no separation of drainage and irrigation caused victims of

farmland (重金屬汙染桃園河川, 灌排不分農地也受害). Retrieved from https://news.tvbs.com.tw/life/914497 (accessed on 2019/02/27)

Water Environment Patrol Strategy Alliance (水環境巡守策略聯盟). (n.d.). Retrieved from http://www2.hwai.edu.tw/water/water-web/profile.html (accessed on 2019/02/27)

Wei, C. Y. (魏瑾筠) (2018). Remediation of Nankan Chi in Taoyuan, the Environmental Protection Bureau extends the total control amount of cooper (桃園整治南崁溪,環局擴大銅總量管制). *Liberty Times* (自由時報), 2018-01-07. Retrieved from http://news.ltn.com.tw/news/local/paper/1166430 (accessed on 2018/01/07)

Appendix Tables

Appendix Table 1: The Quality of Raw Water at Purification Plants and Water Sources of the Taipei Water Department
(Moving average of the data from January to December 2018)

	Examine Items	Unit	Detected limit	Water Purification Plants and Water Sources									
				Zhitan 直潭	Changxing 長興	Shuangxi 雙溪	Shilin 士林	Yangmingshan 1st 陽明山第一水源	Yangmingshan Third 陽明山第三水源	Yangmingshan Forth 陽明山第四水源	Top Beitou 頂北投取水口	Chungshan Building 中山樓水源	BeitouFirst 北投第一水源
1	Water temperature 水溫	°C	--	21.5	21.2	22.1	22.2		22.3	21.4	22.2	20.4	22.6
2	Turbidity 濁度	NTU	--	27	32	8.0	1.0	0.25	0.25	0.25	3.4	2.8	0.40
3	Chroma 色度	UNIT	--	14	15	12	3	2	2	2	9	5	2
4	Smell 臭度	---	--	11	9	13	4	1	2	2	11	3	1
5	Total alkalinity 總鹼度	mg/L	--	24.2	29.1	39.2	65.3	33.7	64.7	55.5	40.6	28.0	76.0
6	pH 值	---	--	7.3	7.3	7.7	6.7	6.7	6.4	6.7	7.8	7.4	7.1
7	Chloride salt 氯鹽	mg/L	0.028	2.85	2.65	10.4	16.2	13.2	42.8	20.2	19.8	19.3	13.6
8	Sulfate 硫酸鹽	mg/L	0.212	10.6	12.0	5.56	16.8	28.0	72.2	34.1	54.3	34.3	31.1
9	Ammonia nitrogen 氨氮	mg/L	0.011	0.01	0.01	ND	ND	ND	ND	ND	0.01	ND	ND
10	Nitrite nitrogen 亞硝酸鹽氮	mg/L	0.00045	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Nitrate nitrogen 硝酸鹽氮	mg/L	0.014	0.55	0.56	0.71	3.25	1.11	1.60	1.92	0.97	0.59	2.38
12	DO 溶氧量	mg/L	--	9.0	8.4	8.5	7.2	8.1	7.2	7.8	7.9	7.7	7.8
13	BOD 生化需氧量	mg/L	--	0.5	0.6	0.4	0.2	0.4	0.2	0.2	0.4	0.4	0.4
14	COD 化學需氧量	mg/L	1.27	3.1	2.8	1.6	2.2	2.0	1.7	1.7	1.8	2.5	2.2
15	TDS 總溶解固體量	mg/L	--	57	59	81	162	119	285	171	177	124	181
16	Suspended solid 懸浮固體量	mg/L	--	74.3	147	17.9	0.2	--	--	--	7.5	1.8	--
17	Conductivity 導電度	μs/cm	--	85	93	122	233	177	418	250	263	194	266
18	Fluorine salt 氟鹽	mg/L	--	0.08	0.08	0.05	0.07	0.05	0.13	0.10	0.11	0.08	0.09
19	Total hardness 總硬度	mg/L	1.00	30.6	36.4	41.5	84.4	62.6	167	93.1	95.9	64.6	102
20	Calcium, Ca 鈣	mg/L	0.39	8.8	9.8	9.9	21.1	17.7	45.6	25.0	26.5	16.9	29.2

21	Magnesium, Mg 鎂	mg/L	--	2.7	2.9	4.1	7.7	4.5	13.0	7.5	7.3	5.4	7.2
22	Iron, Fe 鐵	mg/L	0.00137	0.882	3.36	0.667	0.012	0.004	0.003	0.006	0.255	0.041	0.007
23	Manganese, Mn 錳	mg/L	0.00061	0.020	0.074	0.061	ND	ND	0.002	ND	0.042	0.008	ND
24	Total number of colonies 總菌落數	CFU/mL	--	5.9e+02	9.2e+02	1.6e+03	68	2	12	18	1.5e+03	3.2e+02	49
25	Coliform group 大腸桿菌群	CFU/100mL	--	1.3e+03	2.1e+03	3.7e+03	1.2e+02	4	15	15	5.6e+03	2.3e+03	1.1e+02
26	Coliform group 總有機碳	mg/L	0.03	0.3	0.3	0.6	0.1	0.1	0.1	0.1	0.4	0.3	0.1
27	THMFP 三鹵甲烷前体物	mg/L	--	0.0404	0.0620	0.0915	0.0268	0.0261	0.0169	0.0145	0.0796	0.0703	0.0124
28	Lead, Pb 鉛	mg/L	0.00064	ND	0.0016	ND	ND	ND	ND	ND	ND	ND	ND
29	Aluminum, Al 鋁	mg/L	0.00080	1.10	1.81	3.26	0.021	0.008	0.018	0.006	0.634	0.071	0.012
30	Arsenic, As 砷	mg/L	0.00096	ND	0.001	0.001	0.003	0.001	0.004	0.002	0.002	0.002	0.003
31	Mercury, Hg 汞	mg/L	0.00007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
32	Cadmium, Cd 鎘	mg/L	0.00061	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
33	Chromium, Cr 鉻	mg/L	0.00030	ND	0.002	ND	0.001	ND	ND	ND	ND	ND	ND
34	Silver, Ag 銀	mg/L	0.00052	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
35	Copper, Cu 銅	mg/L	0.00061	0.0006	0.0019	0.0017	ND	ND	0.0048	0.0017	0.0007	ND	0.0008
36	Zinc, Zn 鋅	mg/L	0.00083	0.010	0.015	0.008	0.002	0.002	0.006	0.004	0.005	0.003	0.002
37	Selenium, Se 硒	mg/L	0.00080	0.001	0.001	ND	0.001	ND	0.002	0.001	0.002	0.001	0.002
38	UV_254	--	--	0.0128	0.0125	0.0171	0.0058	0.0042	0.0038	0.0039	0.0139	0.0122	0.0040
39	Lindane 靈丹	mg/L	0.0000022	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
40	Endosulfan 安殺番	mg/L	0.0000062	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
41	Paraquat 巴拉刈	mg/L	0.0048	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
42	Monocrotophos 亞素靈	mg/L	0.000047	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
43	Diazinon 大利松	mg/L	0.000040	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
44	Parathion 巴拉松	mg/L	0.000036	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
45	EPN 一品松	mg/L	0.000038	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

*ND means lower than detected limits.

Source: Taipei Water Department, https://www.water.gov.taipei/cp.aspx?n=F046E45446707A64, Accessed on 2019/01/29

Appendix Table 2: Quality of Tape-Water supplied by Six Water Purification Plants for New Taipei City

	Examine Items	Unit	Limited Standards	Six Water Purification Plants					
				Bansin 板新	Yuanshan 員山	Pinglin 坪林	Linjhuang 林莊	Laomei 老梅	Gongliau 貢寮
1	Free available chlorine 自由有效餘氯	mg/L	0.2-1.0	0.72	0.64	0.70	0.56	0.58	0.69
2	Turbidity 濁度	NTU	2	0.15	0.50	0.40	0.30	0.50	0.20
3	Chroma 色度	鉑鈷單位	5	<5	<5	<5	<5	<5	<5
4	Smell 臭度	初嗅數	3	<1	<1	<1	<1	<1	<1
5	Total alkalinity 總鹼度	mg/L	-	51.2	48.2	27.0	31.4	38.5	25.1
6	pH 值	—	6.0-8.5	7.2	7.7	7.3	7.8	7.7	7.2
7	Chloride salt 氯鹽	mg/L	250	9.48	13.4	8.05	8.56	13.0	15.8
8	Sulfate 硫酸鹽	mg/L	250	26.3	23.1	6.49	8.05	4.45	9.52
9	Ammonia nitrogen 氨氮	mg/L	0.1	0.03	ND	ND	ND	ND	ND
10	Nitrite nitrogen 亞硝酸鹽氮	mg/L	0.1	ND	ND	ND	ND	ND	ND
11	Nitrate nitrogen 硝酸鹽氮	mg/L	10	0.78	0.54	0.78	0.77	0.94	0.43
12	TDS 總溶解固體量	mg/L	500	128	139	60.8	87.7	89.0	90.0
13	Fluorine salt 氟鹽	mg/L	0.8	0.07	0.05	0.03	0.02	0.02	0.03
14	Total hardness 總硬度	mg/L	300	74.4	49.6	20.6	29.1	27.9	29.4
15	Iron, Fe 鐵	mg/L	0.3	ND	0.05	0.07	0.06	0.06	0.02
16	Manganese, Mn 錳	mg/L	0.05	0.002	0.003	ND	ND	ND	ND
17	Total number of colonies 總菌落數	CFU/mL	100	<1	<1	<1	<1	<1	<1
18	Coliform group 大腸桿菌群	CFU/100mL	6	<1	<1	<1	<1	<1	<1
19	THMs 總三鹵甲烷	mg/L	0.08	0.0130	0.0210	0.00328	0.00245	0.0149	0.0204
20	Lead, Pb 鉛	mg/L	0.01	ND	0.0017	0.0011	ND	0.0005	0.0010
21	Selenium, Se 硒	mg/L	0.01	ND	ND	ND	ND	ND	ND
22	Arsenic, As 砷	mg/L	0.01	0.00076	0.00029	0.00011	0.00058	0.00038	ND
23	Mercury, Hg 汞	mg/L	0.002	ND	ND	ND	ND	ND	ND
24	Zinc, Zn 鋅	mg/L	5	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
25	Silver, Ag 銀	mg/L	0.05	ND	ND	ND	ND	ND	ND
26	Copper, Cu 銅	mg/L	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Chromium, Cr 鉻	mg/L	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Nickel, Nl 鎳	mg/L	0.07	0.0014	ND	ND	ND	ND	ND
29	Cadmium, Cd 鎘	mg/L	0.005	ND	ND	ND	ND	ND	ND
30	Barium, Ba 鋇	mg/L	2	0.0147	0.0157	0.0173	0.0025	0.0031	0.0337
31	Antimony, Sb 銻	mg/L	0.01	ND	<0.0001	ND	<0.0001	<0.0001	<0.0001
32	Anionic surfactant 陰離子界面活性劑	mg/L	0.5	ND	ND	ND	ND	ND	ND

33 Lindane 靈丹	mg/L	0.0002	ND	ND	ND	ND	ND	ND
34 Endosulfan 安殺番	mg/L	0.003	ND	ND	ND	ND	ND	ND
35 Paraquat,巴拉刈	mg/L	0.01	ND	ND	ND	ND	ND	ND
36 Diazinon 大利松	mg/L	0.005	ND	ND	ND	ND	ND	ND
37 Parathion 巴拉松	mg/L	0.02	ND	ND	ND	ND	ND	ND
38 EPN 一品松	mg/L	0.005	ND	ND	ND	ND	ND	ND
39 Cyanide salt 氰鹽	mg/L	0.05	ND	ND	ND	ND	ND	ND
40 Phenol 酚	mg/L	0.001	ND	ND	ND	ND	ND	ND
41 Methamidophos 達馬松	mg/L	0.02	ND	ND	ND	ND	ND	ND
42 Butachlor 丁基拉草	mg/L	0.02	ND	ND	ND	ND	ND	ND
43 2,4-D	mg/L	0.07	ND	ND	ND	ND	ND	ND
44 Methomyl 納乃得	mg/L	0.01	ND	ND	ND	ND	ND	ND
45 Fenobucarb 滅必蝨	mg/L	0.02	ND	ND	ND	ND	ND	ND
46 Carbofuran 加保扶	mg/L	0.02	ND	ND	ND	ND	ND	ND
47 Monocrotophos 亞素靈	mg/L	0.003	ND	ND	ND	ND	ND	ND
48 Aluminum, Al 鋁	mg/L	0.3	0.0951	0.148	0.0409	0.0846	0.133	0.0675
49 Bromate 溴酸鹽	mg/L	0.01	ND	ND	ND	ND	ND	ND
50 Fecal coliform 糞便性大腸桿菌群	CFU/100mL	-	<1	<1	－－	－－	－－	<1
51 Trichloroethylene 三氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND	ND
52 Carbon tetrachloride 四氯化碳	mg/L	0.005	ND	ND	ND	ND	ND	ND
53 Trichloroethane1,1,1-三氯乙烷	mg/L	0.2	ND	ND	ND	ND	ND	ND
54 **1**,**2**-dichloroethane1,2-二氯乙烷	mg/L	0.005	ND	ND	ND	ND	ND	ND
55 Vinyl chloride 氯乙烯	mg/L	0.0003	ND	ND	ND	ND	ND	ND
56 Benzene 苯	mg/L	0.005	ND	ND	ND	ND	ND	ND
57 para-Dichlorobenzene 對-二氯苯	mg/L	0.075	ND	ND	ND	ND	ND	ND
58 *1*,*1*-Dichloroethene 1,1-二氯乙烯	mg/L	0.007	ND	ND	ND	ND	ND	ND
59 Dichloromethane 二氯甲烷	mg/L	0.02	ND	ND	ND	ND	ND	ND
60 ODCB 鄰-二氯苯	mg/L	0.6	ND	ND	ND	ND	ND	ND
61 Toluene 甲苯	mg/L	0.7	ND	ND	ND	ND	ND	ND
62 Dimethylbenzene 二甲苯	mg/L	0.5	ND	ND	ND	ND	ND	ND
63 cis-1,2-Dichloroethene 順-1,2-二氯乙烯	mg/L	0.07	ND	ND	ND	ND	ND	ND
64 trans-1,2-Dichloroethylene 反-1,2-二氯乙烯	mg/L	0.1	ND	ND	ND	ND	ND	ND
65 Tetrachloroethylene 四氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND	ND
Qualified or not 水質合格否	Y/N	-	Y	Y	Y	Y	Y	Y

*ND means lower than detected limits.

Source: Taiwan Water Cooperation, https://www.water.gov.tw/ct.aspx?xItem=436094&ctNode=775&mp=1 (2019-01-21), Accessed on 2019/01/29

Appendix Table 3: Quality of Tape-Water Provided by the Five Water Purification Plant in Taoyuan City

	Examine Items	Unit	Limited Standards	Five Water Purification Plants				
				Pingjen 平鎮	Danan 大湳	Shihmen 石門	Longtan 龍潭	Fusing 復興
1	Free available chlorine 自由有效餘氯	mg/L	0.2-1.0	0.69	0.68	0.69	0.70	0.61
2	Turbidity 濁度	NTU	2	0.40	0.35	0.40	0.35	0.50
3	Chroma 色度	鉑鈷單位	5	<5	<5	<5	<5	<5
4	Smell 臭度	初嗅數	3	<1	<1	<1	<1	<1
5	Total alkalinity 總鹼度	mg/L	-	66.8	74.7	70.4	68.6	56.4
6	pH 值	—	6.0-8.5	7.6	7.3	7.6	7.5	7.9
7	Chloride salt 氯鹽	mg/L	250	4.59	8.13	6.06	4.83	4.15
8	Sulfate 硫酸鹽	mg/L	250	34.0	33.9	33.5	31.7	6.27
9	Ammonia nitrogen 氨氮	mg/L	0.1	ND	ND	ND	ND	ND
10	Nitrite nitrogen 亞硝酸鹽氮	mg/L	0.1	ND	ND	ND	<0.01	ND
11	Nitrate nitrogen 硝酸鹽氮	mg/L	10	0.51	0.69	0.55	0.96	0.79
12	TDS 總溶解固體量	mg/L	500	131	138	133	140	98.7
13	Fluorine salt 氟鹽	mg/L	0.8	0.05	0.08	0.06	0.07	0.07
14	Total hardness 總硬度	mg/L	300	83.2	94.6	82.2	83.7	52.2
15	Iron, Fe 鐵	mg/L	0.3	ND	ND	ND	ND	0.05
16	Manganese, Mn 錳	mg/L	0.05	ND	ND	ND	ND	0.011
17	Total number of colonies 總菌落數	CFU/mL	100	<1	<1	<1	<1	<1
18	Coliform group 大腸桿菌群	CFU/100mL	6	<1	<1	<1	<1	<1
19	THMs 總三鹵甲烷	mg/L	0.08	0.00659	0.0122	0.00929	0.00836	0.0183
20	Lead, Pb 鉛	mg/L	0.01	ND	0.0003	ND	0.0002	0.0003
21	Selenium, Se 硒	mg/L	0.01	ND	ND	ND	ND	ND
22	Arsenic, As 砷	mg/L	0.01	0.00026	0.00059	0.00025	0.00037	0.00035
23	Mercury, Hg 汞	mg/L	0.002	ND	ND	ND	ND	ND
24	Zinc, Zn 鋅	mg/L	5	<0.01	<0.01	ND	ND	<0.01
25	Silver, Ag 銀	mg/L	0.05	ND	ND	ND	ND	ND
26	Copper, Cu 銅	mg/L	1	<0.01	<0.01	<0.01	<0.01	<0.01
27	Chromium,Cr 鉻	mg/L	0.05	<0.01	<0.01	ND	ND	<0.01
28	Nickel, Nl 鎳	mg/L	0.07	ND	ND	ND	ND	ND
29	Cadmium, Cd 鎘	mg/L	0.005	ND	ND	ND	ND	ND
30	Barium, Ba 鋇	mg/L	2	0.0061	0.0125	0.0076	0.0088	0.0064
31	Antimony, Sb 銻	mg/L	0.01	0.0001	0.0003	ND	0.0001	ND
32	Anionic surfactant 陰離子界面活性劑	mg/L	0.5	ND	ND	ND	ND	ND
33	Lindane 靈丹	mg/L	0.0002	ND	ND	ND	ND	ND

34	Endosulfan 安殺番	mg/L	0.003	ND	ND	ND	ND	ND
35	Paraquat,巴拉刈	mg/L	0.01	ND	ND	ND	ND	ND
36	Diazinon 大利松	mg/L	0.005	ND	ND	ND	ND	ND
37	Parathion 巴拉松	mg/L	0.02	ND	ND	ND	ND	ND
38	EPN 一品松	mg/L	0.005	ND	ND	ND	ND	ND
39	Cyanide salt 氰鹽	mg/L	0.05	ND	ND	ND	ND	ND
40	Phenol 酚	mg/L	0.001	ND	ND	ND	ND	ND
41	Methamidophos 達馬松	mg/L	0.02	ND	ND	ND	ND	ND
42	Butachlor 丁基拉草	mg/L	0.02	ND	ND	ND	ND	ND
43	2,4-D	mg/L	0.07	ND	ND	ND	ND	ND
44	Methomyl 納乃得	mg/L	0.01	ND	ND	ND	ND	ND
45	Fenobucarb 滅必蝨	mg/L	0.02	ND	ND	ND	ND	ND
46	Carbofuran 加保扶	mg/L	0.02	ND	ND	ND	ND	ND
47	Monocrotophos 亞素靈	mg/L	0.003	ND	ND	ND	ND	ND
48	Aluminum, Al 鋁	mg/L	0.3	0.0928	0.106	0.0929	0.0638	0.0670
49	Bromate 溴酸鹽	mg/L	0.01	ND	ND	ND	ND	ND
50	Fecal coliform 糞便性大腸桿菌群	CFU/100mL	-	<1	<1	<1	<1	－－
51	Trichloroethylene 三氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND
52	Carbon tetrachloride 四氯化碳	mg/L	0.005	ND	ND	ND	ND	ND
53	1,1,1Trichloroethane 1,1,1-三氯乙烷	mg/L	0.2	ND	ND	ND	ND	ND
54	1,2-dichloroethane 1,2-二氯乙烷	mg/L	0.005	ND	ND	ND	ND	ND
55	Vinyl chloride 氯乙烯	mg/L	0.0003	ND	ND	ND	ND	ND
56	Benzene 苯	mg/L	0.005	ND	ND	ND	ND	ND
57	para-Dichlorobenzene 對-二氯苯	mg/L	0.075	ND	ND	ND	ND	ND
58	*1,1*-Dichloroethene 1,1-二氯乙烯	mg/L	0.007	ND	ND	ND	ND	ND
59	Dichloromethane 二氯甲烷	mg/L	0.02	ND	0.00473	ND	ND	ND
60	ODCB 鄰-二氯苯	mg/L	0.6	ND	ND	ND	ND	ND
61	Toluene 甲苯	mg/L	0.7	ND	ND	ND	ND	ND
62	Dimethylbenzene 二甲苯	mg/L	0.5	ND	ND	ND	ND	ND
63	cis-1,2-Dichloroethene 順-1,2-二氯乙烯	mg/L	0.07	ND	ND	ND	ND	ND
64	trans-1,2-Dichloroethylen 反-1,2-二氯乙烯	mg/L	0.1	ND	ND	ND	ND	ND
65	Tetrachloroethylene 四氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND
	Qualified or not 水質合格否	Y/N	-	Y	Y	Y	Y	Y

*ND means lower than detected limits.

Sources: Taiwan Water Cooperation, https://www.water.gov.tw/ct.aspx?xItem=436100&ctNode=775&mp=1 (2019-01-21)
Accessed on 2019/01/29

Appendix Table 4: Tape-Water Quality of the Nine Water Purification Plants in Taichung City

	Examine Items	Unit	Limited Standards	Nine Water Purification Plants								
				Fongyuan 豐原	Liyutan 鯉魚潭	Wufong 霧峰	Daan 大安	Dadu 大肚	Guguan 谷關	Cingdong 慶東	Lishan 梨山	Sinshe 新社
1	Free available chlorine 自由有效餘氯	mg/L	0.2-1.0	0.74	0.63	0.46	0.51	0.41	0.65	0.60	0.46	0.47
2	Turbidity 濁度	NTU	2	0.50	0.35	0.60	0.20	0.25	0.20	0.55	0.50	0.40
3	Chroma 色度	鉑鈷單位	5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4	Smell 臭度	初嗅數	3	<1	<1	<1	<1	<1	<1	<1	<1	<1
5	Total alkalinity 總鹼度	mg/L	-	79.6	98.6	156	112	85.2	37.1	89.4	78.2	21.3
6	pH 值	—	6.0-8.5	7.7	7.7	7.0	7.2	7.7	7.9	7.5	8.1	7.0
7	Chloride salt 氯鹽	mg/L	250	5.56	2.61	11.1	8.88	25.9	2.99	3.17	1.03	5.84
8	Sulfate 硫酸鹽	mg/L	250	34.9	76.8	60.4	58.2	40.3	6.06	35.4	12.8	23.4
9	Ammonia nitrogen 氨氮	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	Nitrite nitrogen 亞硝酸鹽氮	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Nitrate nitrogen 硝酸鹽氮	mg/L	10	0.84	0.42	2.56	2.00	3.15	0.35	1.20	0.38	6.30
12	TDS 總溶解固體量	mg/L	500	168	234	310	242	244	72.0	180	120	120
13	Fluorine salt 氟鹽	mg/L	0.8	0.11	0.12	0.11	0.08	0.14	0.05	0.12	0.07	0.03
14	Total hardness 總硬度	mg/L	300	115	161	169	161	110	41.3	117	86.1	54.6
15	Iron, Fe 鐵	mg/L	0.3	0.07	ND	0.05	ND	0.01	ND	0.03	0.02	0.02
16	Manganese, Mn 錳	mg/L	0.05	ND	ND	0.002	ND	0.005	ND	ND	ND	0.009
17	Total number of colonies 總菌落數	CFU/mL	100	1	<1	1	<1	<1	3	<1	16	<1
18	Coliform group 大腸桿菌群	CFU/100mL	6	<1	<1	<1	<1	<1	<1	<1	<1	<1
19	THMs 總三鹵甲烷	mg/L	0.08	0.00959	0.00486	0.00145	0.00087	0.00734	0.00826	0.00102	0.00435	0.00141
20	Lead, Pb 鉛	mg/L	0.01	ND	ND	ND	ND	ND	0.0015	0.0016	ND	0.0014
21	Selenium, Se 硒	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
22	Arsenic, As 砷	mg/L	0.01	0.00206	0.00276	0.00015	0.00066	0.00029	0.00088	0.00041	0.00021	0.00013
23	Mercury, Hg 汞	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND
24	Zinc, Zn 鋅	mg/L	5	0.03	ND	0.01	<0.01	<0.01	0.02	0.03	ND	<0.01
25	Silver, Ag 銀	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
26	Copper, Cu 銅	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	ND
27	Chromium,Cr 鉻	mg/L	0.05	0.01	0.01	ND	ND	<0.01	ND	ND	ND	<0.01
28	Nickel, Nl 鎳	mg/L	0.07	0.0024	0.0009	0.0006	0.0011	ND	0.0018	0.0016	ND	ND
29	Cadmium, Cd 鎘	mg/L	0.005	0.0005	ND	ND	ND	ND	ND	ND	ND	ND
30	Barium, Ba 鋇	mg/L	2	0.0040	0.0063	0.0034	0.0025	0.0032	ND	0.0043	0.0005	0.0823
31	Antimony, Sb 銻	mg/L	0.01	0.0003	0.0002	ND	ND	ND	ND	ND	ND	ND
32	Anionic surfactant 陰離子界面活性劑	mg/L	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
33	Lindane 靈丹	mg/L	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND

34 Endosulfan 安殺番	mg/L	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND
35 Paraquat,巴拉刈	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
36 Diazinon 大利松	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
37 Parathion 巴拉松	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND
38 EPN 一品松	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
39 Cyanide salt 氰鹽	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
40 Phenol 酚	mg/L	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
41 Methamidophos 達馬松	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND
42 Butachlor 丁基拉草	mg/L	0.02	0.00002	0.00003	ND	ND	ND	0.00004	ND	ND	ND
43 2,4-D	mg/L	0.07	ND	ND	ND	ND	0.0002	ND	ND	ND	ND
44 Methomyl 納乃得	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
45 Fenobucarb 滅必蝨	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND
46 Carbofuran 加保扶	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND
47 Monocrotophos 亞素靈	mg/L	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND
48 Aluminum, Al 鋁	mg/L	0.3	0.109	0.0829	0.0401	0.00509	0.0415	0.0175	0.0257	0.0349	0.0275
49 Bromate 溴酸鹽	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
50 Fecal coliform 糞便性大腸桿菌群	CFU/100mL	-	<1	<1	<1	<1	－－	－－	－－	－－	－－
51 Trichloroethylene 三氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
52 Carbon tetrachloride 四氯化碳	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
53 1,1,1Trichloroethane 1,1,1-三氯乙烷	mg/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
54 1,2-dichloroethane 1,2-二氯乙烷	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
55 Vinyl chloride 氯乙烯	mg/L	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND
56 Benzene 苯	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
56 para-Dichlorobenzene 對-二氯苯	mg/L	0.075	ND	ND	ND	ND	ND	ND	ND	ND	ND
58 *1,1*-Dichloroethene 1,1-二氯乙烯	mg/L	0.007	ND	ND	ND	ND	0.00009	ND	ND	ND	ND
59 Dichloromethane 二氯甲烷	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	0.00002	ND
60 ODCB 鄰-二氯苯	mg/L	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND
61 Toluene 甲苯	mg/L	0.7	ND	ND	0.00032	0.00002	ND	ND	ND	ND	ND
62 Dimethylbenzene 二甲苯	mg/L	0.5	ND	ND	ND	0.00002	ND	0.00047	0.00051	0.00033	ND
63 cis-1,2-Dichloroethene 順-1,2-二氯乙烯	mg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND
64 trans-1,2-Dichloroethylene 反-1,2-二氯乙烯	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
65 Tetrachloroethylene 四氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
Qualified or not 水質合格否	Y/N	-	Y	Y	Y	Y	Y	Y	Y	Y	Y

*ND means lower than detected limits.
Source: Taiwan Water Cooperation, https://www.water.gov.tw/ct.aspx?xItem=436124&ctNode=775&mp=1 (2019-01-21)
Accessed on 2019/01/29

Appendix Table 5: Tap Water Quality Provided by Four Water Purification Plants in Tainan City

	Examine Items	Unit	Linited Standards	Four Water Purification Plants			
				Wushantou 烏山頭	Tanting 潭頂	Nanhua 南化	Nanyu 楠玉
1	Free available chlorine 自由有效餘氯	mg/L	0.2-1.0	0.80	0.68	0.84	0.73
2	Turbidity 濁度	NTU	2	0.30	0.25	0.25	0.45
3	Chroma 色度	鉑鈷單位	5	<5	<5	<5	<5
4	Smell 臭度	初嗅數	3	<1	<1	<1	<1
5	Total alkalinity 總鹼度	mg/L	-	121	135	124	130
6	pH 值	—	6.0-8.5	7.8	7.7	8.0	7.8
7	Chloride salt 氯鹽	mg/L	250	6.73	14.6	6.57	16.1
8	Sulfate 硫酸鹽	mg/L	250	35.3	41.4	49.7	39.2
9	Ammonia nitrogen 氨氮	mg/L	0.1	0.02	0.02	0.01	0.01
10	Nitrite nitrogen 亞硝酸鹽氮	mg/L	0.1	<0.01	<0.01	ND	<0.01
11	Nitrate nitrogen 硝酸鹽氮	mg/L	10	0.40	0.44	0.21	0.42
12	TDS 總溶解固體量	mg/L	500	178	214	210	215
13	Fluorine salt 氟鹽	mg/L	0.8	0.14	0.17	0.15	0.14
14	Total hardness 總硬度	mg/L	300	121	137	143	125
15	Iron, Fe 鐵	mg/L	0.3	0.05	0.02	0.03	0.08
16	Manganese, Mn 錳	mg/L	0.05	<0.001	0.001	<0.001	0.006
17	Total number of colonies 總菌落數	CFU/mL	100	<1	<1	<1	<1
18	Coliform group 大腸桿菌群	CFU/100mL	6	<1	<1	<1	<1
19	THMs 總三鹵甲烷	mg/L	0.08	0.0120	0.0298	0.0161	0.0186
20	Lead, Pb 鉛	mg/L	0.01	0.0010	ND	0.0004	0.0002
21	Selenium, Se 硒	mg/L	0.01	ND	ND	ND	ND
22	Arsenic, As 砷	mg/L	0.01	0.00090	0.00072	0.00089	0.00101
23	Mercury, Hg 汞	mg/L	0.002	ND	ND	ND	ND
24	Zinc, Zn 鋅	mg/L	5	<0.01	<0.01	<0.01	<0.01
25	Silver, Ag 銀	mg/L	0.05	ND	ND	ND	<0.01
26	Copper, Cu 銅	mg/L	1	<0.01	<0.01	<0.01	<0.01
27	Chromium,Cr 鉻	mg/L	0.05	<0.01	<0.01	<0.01	<0.01
28	Nickel, Nl 鎳	mg/L	0.07	ND	0.0004	ND	ND
29	Cadmium, Cd 鎘	mg/L	0.005	ND	ND	ND	ND
30	Barium, Ba 鋇	mg/L	2	0.0174	0.0158	0.0270	0.0260
31	Antimony, Sb 銻	mg/L	0.01	0.0002	0.0001	0.0002	0.0002
32	Anionic surfactant 陰離子界面活性劑	mg/L	0.5	0.01	0.01	0.02	0.01

33 Lindane 靈丹	mg/L	0.0002	ND	ND	ND	ND
34 Endosulfan 安殺番	mg/L	0.003	ND	ND	ND	ND
35 Paraquat,巴拉刈	mg/L	0.01	ND	ND	ND	ND
36 Diazinon 大利松	mg/L	0.005	ND	ND	ND	ND
37 Parathion 巴拉松	mg/L	0.02	ND	ND	ND	ND
38 EPN 一品松	mg/L	0.005	ND	ND	ND	ND
39 Cyanide salt 氰鹽	mg/L	0.05	ND	ND	ND	ND
40 Phenol 酚	mg/L	0.001	ND	ND	ND	ND
41 Methamidophos 達馬松	mg/L	0.02	ND	ND	ND	ND
42 Butachlor 丁基拉草	mg/L	0.02	ND	ND	ND	ND
43 2,4-D	mg/L	0.07	ND	ND	ND	ND
44 Methomyl 納乃得	mg/L	0.01	ND	ND	ND	ND
45 Fenobucarb 滅必蝨	mg/L	0.02	ND	ND	ND	ND
46 Carbofuran 加保扶	mg/L	0.02	ND	ND	ND	ND
47 Monocrotophos 亞素靈	mg/L	0.003	ND	ND	ND	ND
48 Aluminum, Al 鋁	mg/L	0.3	0.124	0.0706	0.116	0.124
49 Bromate 溴酸鹽	mg/L	0.01	ND	0.0002	ND	ND
50 Fecal coliform 糞便性大腸桿菌群	CFU/100mL	-	-	-	<1	－－
51 Trichloroethylene 三氯乙烯	mg/L	0.005	ND	ND	ND	ND
52 Carbon tetrachloride 四氯化碳	mg/L	0.005	ND	ND	ND	ND
53 1,1,1Trichloroethane1,1,1-三氯乙烷	mg/L	0.2	ND	ND	ND	ND
54 **1**,**2**-dichloroethane 1,2-二氯乙烷	mg/L	0.005	ND	ND	ND	ND
55 Vinyl chloride 氯乙烯	mg/L	0.0003	ND	ND	ND	ND
56 Benzene 苯	mg/L	0.005	ND	ND	ND	ND
57 para-Dichlorobenzene 對-二氯苯	mg/L	0.075	ND	ND	ND	ND
58 *1*,*1*-Dichloroethene 1,1-二氯乙烯	mg/L	0.007	ND	ND	ND	ND
59 Dichloromethane 二氯甲烷	mg/L	0.02	ND	ND	ND	ND
60 ODCB 鄰-二氯苯	mg/L	0.6	ND	ND	ND	ND
61 Toluene 甲苯	mg/L	0.7	ND	ND	ND	ND
62 Dimethylbenzene 二甲苯	mg/L	0.5	0.00029	0.00016	ND	0.00029
63 cis-1,2-Dichloroethene 順-1,2-二氯乙烯	mg/L	0.07	ND	ND	ND	ND
64 trans-1,2-Dichloroethylene 反-1,2-二氯乙烯	mg/L	0.1	ND	ND	ND	ND
65 Tetrachloroethylene 四氯乙烯	mg/L	0.005	ND	ND	ND	ND
Qualified or not 水質合格否	Y/N	-	Y	Y	Y	Y

*ND means lower than detected limits.

Source: Taiwan Water Cooperation,https://www.water.gov.tw/ct.aspx?xItem=436152&ctNode=775&mp=1,Accessed on 2019/01/29

Appendix Table 6: TapWater Quality provided by 14 Water Purification Plants in Kaohsiung City

	Examine Items	Unit	14 Water Purification Plants														
			Limited Standards	Chengching Lake 澄清湖	Fongshan 鳳山	Pinding 坪頂	Kaotan 拷潭	Chiahsien 甲仙	Liouguei 六龜	Muzih 木梓	Minsheng 民生	Duona 多納	Meinong 美濃	Maolin 茂林	Sinwei 新威	Shoujinliao 手巾寮	Baolai 寶來
1	Free available chlorine 自由有效餘氯	mg/L	0.2-1.0	0.56	0.66	0.73	0.73	0.50	0.57	0.61	0.60	0.54	0.59	0.51	0.55	0.49	0.57
2	Turbidity 濁度	NTU	2	0.10	0.10	0.30	0.10	0.30	0.25	0.15	0.30	0.15	0.25	0.15	0.35	0.20	0.20
3	Chroma 色度	鉑鈷單位	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4	Smell 臭度	初嗅數	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
5	Total alkalinity 總鹼度	mg/L	-	108	104	152	138	143	151	198	67.0	90.1	230	119	147	186	207
6	pH 值	—	6.0-8.5	7.6	7.5	7.5	7.2	7.8	7.9	7.7	7.7	7.6	7.4	7.6	7.9	7.6	7.9
7	Chloride salt 氯鹽	mg/L	250	11.8	10.6	13.8	13.1	5.60	6.15	7.20	7.41	3.25	7.92	2.84	7.98	5.48	13.9
8	Sulfate 硫酸鹽	mg/L	250	107	118	97.9	81.9	81.4	102	63.1	14.1	33.7	57.4	83.7	91.9	113	125
9	Ammonia nitrogen 氨氮	mg/L	0.1	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	Nitrite nitrogen 亞硝酸鹽氮	mg/L	0.1	ND	ND	ND	ND	<0.01	ND	<0.01	<0.01	ND	ND	ND	ND	<0.01	<0.01
11	Nitrate nitrogen 硝酸鹽氮	mg/L	10	0.49	1.10	0.55	0.45	0.21	0.18	0.84	0.52	0.11	2.11	0.64	0.23	1.17	0.06
12	TDS 總溶解固體量	mg/L	500	290	311	319	294	278	295	306	108	160	351	264	303	396	416
13	Fluorine salt 氟鹽	mg/L	0.8	0.10	0.09	0.11	0.09	0.13	0.12	0.14	0.05	0.09	0.14	0.16	0.11	0.13	0.19
14	Total hardness 總硬度	mg/L	300	158	142	216	181	180	212	221	72.9	106	255	190	198	278	265
15	Iron, Fe 鐵	mg/L	0.3	0.01	<0.01	0.01	0.02	0.02	<0.01	0.01	0.02	<0.01	0.01	ND	0.01	0.03	0.01
16	Manganese, Mn 錳	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.004	ND
17	Total number of colonies 總菌落數	CFU/mL	100	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
18	Coliform group 大腸桿菌群	CFU/100mL	6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
19	THMs 總三鹵甲烷	mg/L	0.08	0.00417	0.00861	0.0151	0.0113	0.0236	0.00395	0.0174	0.0116	0.00311	0.00015	0.00477	0.00158	0.00538	0.00362
20	Lead, Pb 鉛	mg/L	0.01	0.0005	0.0009	ND	ND	0.0002	0.0010	0.0006	0.0007	0.0004	0.0013	0.0003	0.0006	0.0010	0.0004
21	Selenium, Se 硒	mg/L	0.01	0.0002	0.0003	ND	ND	ND	0.0004	ND	ND	0.0006	ND	ND	0.0003	0.0007	ND
22	Arsenic, As 砷	mg/L	0.01	0.00135	0.00116	0.00130	0.00142	0.00077	0.00121	0.00123	0.00074	0.00053	0.00124	0.00117	0.00118	0.00211	0.00178
23	Mercury, Hg 汞	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	0.0005	ND	ND	ND	ND	0.0002	ND
24	Zinc, Zn 鋅	mg/L	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Silver, Ag 銀	mg/L	0.05	ND	<0.01	<0.01	ND	ND	<0.01	<0.01	ND	<0.01	ND	<0.01	ND	<0.01	<0.01
26	Copper, Cu 銅	mg/L	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Chromium,Cr 鉻	mg/L	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Nickel, Nl 鎳	mg/L	0.07	ND	0.0008	ND	ND	0.0012	0.0017	0.0010	0.0011	0.0016	0.0008	ND	0.0007	0.0011	0.0014
29	Cadmium, Cd 鎘	mg/L	0.005	ND	ND	ND	ND	ND	ND	<0.0001	ND	ND	ND	ND	ND	<0.0001	ND
30	Barium, Ba 鋇	mg/L	2	0.0135	0.0138	0.0252	0.0368	0.0396	0.0271	0.0402	0.0173	0.0017	0.0326	0.0014	0.0178	0.0199	0.0258

31	Antimony, Sb 銻	mg/L	0.01	0.0003	0.0004	0.0002	0.0001	0.0002	0.0003	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0002	ND
32	Anionic surfactant 陰離子界面活性劑	mg/L	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
33	Lindane 靈丹	mg/L	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
34	Endosulfan 安殺番	mg/L	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
35	Paraquat,巴拉刈	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
36	Diazinon 大利松	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
37	Parathion 巴拉松	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
38	EPN 一品松	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
39	Cyanide salt 氰鹽	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
40	Phenol 酚	mg/L	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
41	Methamidophos 達馬松	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
42	Butachlor 丁基拉草	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
43	2,4-D	mg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
44	Methomyl 納乃得	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
45	Fenobucarb 滅必蝨	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
46	Carbofuran 加保扶	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
47	Monocrotophos 亞素靈	mg/L	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
48	Aluminum, Al 鋁	mg/L	0.3	0.162	0.126	0.121	0.0551	0.126	0.112	0.0403	0.0469	ND	0.0127	0.0108	0.0537	0.0271	0.0186
49	Bromate 溴酸鹽	mg/L	0.01	0.0035	0.0034	0.0002	0.0002	0.0005	ND	0.0006	0.0013	0.0005	0.0005	0.0006	0.0022	0.0006	0.0004
50	Fecal coliform 糞便性大腸桿菌群	CFU/100mL	-	<1	<1	<1	<1	<1	<1	－－	－－	－－	－－	－－	－－	－－	－－
51	Trichloroethylene 三氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
52	Carbon tetrachloride 四氯化碳	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
53	1,1,1Trichloroethane 1,1,1-三氯乙烷	mg/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
54	**1**,**2**-dichloroethane 1,2-二氯乙烷	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
55	Vinyl chloride 氯乙烯	mg/L	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
56	Benzene 苯	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
57	para-Dichlorobenzene 對-二氯苯	mg/L	0.075	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
58	*1,1*-Dichloroethene 1,1-二氯乙烯	mg/L	0.007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
59	Dichloromethane 二氯甲烷	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
60	ODCB 鄰-二氯苯	mg/L	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
61	Toluene 甲苯	mg/L	0.7	ND	ND	ND	ND	ND	ND	ND	ND	0.00017	ND	0.00020	ND	ND	ND

62	Dimethylbenzene 二甲苯	mg/L	0.5	ND	ND	ND	0.00015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
63	cis-1,2-Dichloroethene 順-1,2-二氯乙烯	mg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
64	trans-1,2-Dichloroethylene 反-1,2-二氯乙烯	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
65	Tetrachloroethylene 四氯乙烯	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Qualified or not 水質合格否	Y/N	-	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

*ND means lower than detected limits.
Source: Taiwan Water Cooperation, https://www.water.gov.tw/ct.aspx?xItem=436152&ctNode=775&mp=1, Accessed on 2019/01/29

Appendix Table 8: Summary comparison of water quality of Taipei City with U.S., Japan、E.U., W.H.O. guidelines (2018-01-22)

Parameters	**Taipei Water quality (tap water)**	**Drinking Water Regulations**				
		Taiwan 2018	**U.S. 2012**	**Japan 2015**	**E.U. 2015**	**W.H.O. 2011**
一、細菌性(Microbial parameters)：						
1. 大腸桿菌群（個/100ml） Total Coliforms (CFU/100ml,MPN/100ml)	<1	6	5.0%[*1][*2] MCLG=0	0[*3]	0	0
2. 總菌落數(個/ml) Total bacterial Count (CFU/ml)	<1	100	MCLG=0	100	[*4] (22˚C)	0
二、物理性(Physical parameters）：						
1. 臭度（初嗅數）Odor (TON)	1	3	3[*5]	[*4]	[*4]	[*4]
2. 濁度 Turbidity (NTU）	0.18	2	TT[*6]	2	[*4]	1.5
3. 色度（鉑鈷單位）Color (Pt-_Co units)	2	5	15[*5]	5	[*4]	5
三、化學性(Chemical parameters）：						
(一)、影響健康物質 (Substances affecting health)：						
1. 砷(Arsenic)（As）	ND (< 0.00079)	0.01	0.01	0.01	0.01	0.01
2. 鉛(Lead)（Pb）	ND (< 0.00064)	0.01	0.015[*7]	0.01	0.01	0.01
3. 硒(Selenium)（Se）	ND (< 0.00154)	0.01	0.05	0.01	0.01	0.01
4. 鉻(總鉻)(Chromium)（Cr）	ND (< 0.00022）	0.05	0.1	0.05(Cr^{6+})	0.05	0.05
5. 鎘(Cadmium) （Cd）	ND (0.00042)	0.005	0.005	0.003	0.005	0.003
6. 鋇(Barium) (Ba)	0.006 (<0.00037)	2.0	2.0	-	-	0.7
7. 銻(Antimony) (Sb)	ND (0.00073)	0.01	0.006	-	0.005	0.02
8. 鎳(Nickle) (Ni)	ND (< 0.00023)	0.07	-	-	0.02	0.07
9. 汞(Mercury) （Hg）	ND (< 0.00008)	0.002	0.002	0.0005	0.001	0.006
10. 氰鹽(Cyanide)（CN^-）	ND (< 0.003)	0.05	0.2	0.01	0.05	-
11. 亞硝酸鹽氮（NO_2^--N）(Nitrite Nitrogen) (As N)	ND (< 0.0005)	0.1	1	0.04	0.1	3

消毒副產物(Disinfection by-product)：						
12. 總三鹵甲烷(Trihalomethanes)（THMs）	0.0051	0.08	0.08	0.1	0.1	*8
13. 鹵乙酸類(Haloacetic acids) (本管制項目濃度係以檢測一氯乙酸(Monochloroacetic acid, MCAA)、二氯乙酸(Dichloroacetic acid, DCAA)、三氯乙酸(Trichloroacetic acid, TCAA)、一溴乙酸(Monobromoacetic acid, MBAA)及二溴乙酸(Dibromoacetic acid, DBAA)等共 5 項化合物(HAA5)所得濃度之總和計算之。)	0.00603	0.060	0.06	一氯乙酸 0.02 二氯乙酸 0.03 三氯乙酸 0.03	-	一氯乙酸 0.02 三氯乙酸 0.02
14. 溴酸鹽(Bromate)	ND (<0.00045)	0.01	0.01	0.01	0.01	0.01
15. 亞氯酸鹽(Chlorite) (僅限添加氣態二氧化氯消毒之供水系統)	ND (<0.00082)	0.7	1	-	-	0.7
揮發性有機物(Volatile organics)：						
16. 三氯乙烯(Trichloroethylene)	ND (<0.000028)	0.005	0.005	0.01	*9	0.02
17. 四氯化碳(Carbon tetrachloride)	ND (<0.000031)	0.005	0.005	0.002	-	0.004
18. 1,1,1-三氯乙烷(1,1,1-Trichloroethane)	ND (<0.000023)	0.20	0.20	0.06	-	-
19. 1,2-二氯乙烷(1,2,-Dichloroethane)	ND (<0.000036)	0.005	0.005	-	0.003	0.03
20.氯乙烯(Vinyl chloride)	ND (<0.00033)	0.0003	0.002	-	0.0005	0.0003
21. 苯(Benzene)	ND (<0.0003)	0.005	0.005	0.01	0.001	0.01
22. 對-二氯苯(para-Dichlorobenzene)	ND (<0.000028)	0.075	0.075	-	-	0.3
23. 1,1-二氯乙烯(1,1Dichloroethylene)	ND (<0.000028)	0.007	0.007	0.04	-	-
24. 二氯甲烷(Dichloromethane)	ND (<0.00062)	0.02	0.005	0.02	-	0.02
25. 鄰-二氯苯(1,2-Dichlorobenzene)	ND (<0.00035)	0.6	0.6	-	-	1
26. 甲苯(Toluene)	ND (<0.00036)	0.7	1	-	-	0.7
27. 二甲苯(Xylenes) (本管制項目濃度係以檢測鄰-二甲苯(1,2-Xylene)、間-二甲苯(1,3-Xylene)、對-二甲苯(1,4-Xylene)等共 3 項同分異構物所得濃度之總和計算之。)	ND (<0.000072)	0.5	10	-	-	0.5
28. 順-1,2-二氯乙烯(cis-1,2-Dichloroethene)	ND (<0.00003)	0.07	0.07	0.04*10	-	-
29. 反-1,2-二氯乙烯(trans-1,2-Dichloroethene)	ND(<0.000023)	0.1	0.1	0.04*10	-	-
30. 四氯乙烯(Tetrachloroethene)	ND(<0.000032)	0.005	0.005	0.01	*9	0.04
農藥(Pesticides)：						
31. 安殺番(Endosulfan)	ND (<0.000003)	0.003	-	-	*12	-
32. 靈丹(Lindane)	ND(<0.0000019)	0.0002	0.0002	-	*12	0.002
33. 丁基拉草(Butachlor)	ND (<0.00024)	0.02	-	-	*12	-
34. 2,4-地(2,4-Dichlorooxyacetic acid)	ND (<0.00017)	0.07	0.07	-	*12	0.03
35.巴拉刈*11(Paraquat)	ND (<0.0044)	0.01	-	-	*12	-
36. 納乃得(Methomyl)	ND (<0.00239)	0.01	-	-	*12	-
37. 加保扶(Carbofuran)	ND (<0.00236)	0.02	0.04	-	*12	0.007

38. 滅必蝨(Isoprocarb)	ND (<0.00249)	0.02	-	-	*12	-
39. 達馬松(Methamidophos)	ND (<0.00255)	0.02	-	-	*12	-
40. 大利松 (Diazinon)	ND(<0.00000144)	0.005	-	-	*12	-
41. 巴拉松(Parathion)	ND(<0.0000026)	0.02	-	-	*12	-
42. 一品松(EPN)	ND(<0.0000119)	0.005	-	-	*12	-
43. 亞素靈(Monocrotophos)	ND(<0.0000478)	0.003	-	-	*12	-
持久性有機汙染物(Persistent organic pollutants, POPs)：						
44. 戴奧辛(Dioxin)(pg WHO-TEQ/L) *15	0.002	3	3	-	-	-
(二)、可能影響健康物質（Substances probably affecting health）：						
1. 氟鹽(Fluoride) （F^-）	0.04	0.8	4.0[*13]	0.8	1.5	1.5
2. 硝酸鹽氮 (Nitrate Nitrogen ， As N) （NO_3-N)	0.67	10.0	10.0	10	50	50
3. 銀(Silver)（Ag）	ND	0.05	0.1[*5]	-	-	-
(三)、影響適飲性物質（Substances probably affecting palatability ）：						
1. 鐵 (Iron)（Fe）	0.001	0.3	0.3[*5]	0.3	0.2	0.1
2. 錳 (Manganese)（Mn）	0.002	0.05	0.05[*5]	0.05	0.05	0.05
3. 銅 (Copper)（Cu）	ND (<0.00056)	1.0	1.0[*5] 1.3[*7]	1.0	2.0	2.0
4. 鋅 (Zinc)（Zn）	0.002	5.0	5.0[*5]	1.0	-	-
5. 硫酸鹽 (Sulfate)（SO_4^{-2}）	10.1	250	250[*5]	-	250	-
6. 酚類 (Phenols)	ND (<0.0009)	0.001	-	0.005	-	-
7. 陰離子界面活性劑（MBAS） (Anionic Surfactant，Methylene Blue Activated Substance)	ND (<0.03)	0.5	-	0.2	-	-
8. 氯鹽 (Chloride) （Cl^-）	7.8	250	250[*5]	200	250	-
9. 氨氮（NH_3-N）(Ammonia Nitrogen ， As N)	ND (<0.011)	0.1	-	-	0.5	-
10. 總硬度[*14] (Total Hardness ， as $CaCO_3$）	37.5	300	-	-	-	-
11.總溶解固體量 (Total Dissolved Solids)	65	500	500[*5]	500	-	-
12. 鋁 (Aluminium) (本管制項目濃度係以檢測總鋁形式之濃度)	0.051	0.3	0.05~0.2[*5]	0.2	0.2	0.1
四、自由有效餘氯（Residual chlorine）	0.58	0.2~1.0	4	-	-	0.5-1.5
五、pH 值 (pH value)	7.2	6.0~8.5	6.5~8.5[*5]	5.8~8.6	6.5~9.5	8.2~8.8(25˚C)

ND :不得檢出(Non detected）

MCLG : Maximum Contaminant Level Goal。

NTU = nephelometric turbidity unit

*1. 每月樣品檢測出大腸桿菌群不可超過總樣品數之 5%。

*2. 飲用水檢測出糞便性大腸桿菌群及大腸桿菌表示水中遭受人或動物之糞便性污染。

*3. 日本厚生省飲用水水質標準為大腸桿菌。

*4. 消費者可接受，無不正常改變。

*5. 美國國家二級飲用水水質標準。

*6. TT：依處理技術要求規範(Treatment technique required)。

*7. 根據美國鉛銅法則(Lead & Copper Rule)訂定以行動標準(Action level)，銅行動標準值為 1.3mg/L（毫克/公升），鉛為 0.015mg/L（毫克/公升），超過該值者自來水事業必須採取防蝕之水質改善。

*8. 總三鹵甲烷各項化合物濃度與 WHO[4th] 指引值之比值總和不得超過 1。

*9. 三氯乙烯與四氯乙烯濃度總和不得超過 0.01mg/L（毫克/公升）。

*10.順-1,2-二氯乙烯與反-1,2-二氯乙烯總和不得超過 0.04 mg/L（毫克/公升）。

*11.paraquat (as dichloride), quivalent to 0.007 mg/L for paraquat ion.

*12.個別項目限值 0.0001（毫克/公升)，總和限值 0.0005 mg/L（毫克/公升）。

*13.美國同時在次要標準中對氟鹽訂定限值為 2 mg/L（毫克/公升）。

*14.一般硬度介於 80~100 毫克/公升 (as $CaCO_3$)是被大眾所接受，大於 200 毫克/公升則不佳但仍可忍受，大於 500 毫克/公升則為大眾無法接受之濃度。

*15. 本管制項目濃度係以檢測 2,3,7,8-四氯戴奧辛(2,3,7,8-Tetrachlorinated dibenzo-p-dioxin,2,3,7,8-TeCDD)， 2,3,7,8-四氯呋喃(2,3,7,8-Tetra chlorinated dibenzofuran,2,3,7,8-TeCDF)及 2,3,7,8-氯化之五氯(Penta-)，六氯(Hexa-)，七氯(Hepta-)與八氯(Octa-)戴奧辛及喃呋等共十七項化合物所得濃度，乘以世界衛生組織所訂戴奧辛毒性當量因子(WHO-TEFs)之總和計算之，並以總毒性當量(TEQ)表示。淨水場周邊五公里範圍內有大型污染源者，應每年檢驗一次，如連續兩年檢測值未超過最大限值，自次年起檢驗頻率得改為兩年一次。

Source: 水質標準與各國水質標準比較表, https://www.water.gov.taipei/cp.aspx?n=B96B3009F7951CD4, accessed on 2019/01/30.