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From panchuran to waterleiding: clean water solutions in Colonial Bandung, West Java, Dutch East Indies (1898–1934)

Abstract. *This study examines clean water management in Bandung, West Java, Dutch East Indies (Indonesia), from the late 19th Century to the early 20th Century. This study focuses on how the human community has modified the physical water unit, including technology, management skills, and social and environmental priorities. Historical methods were applied to investigate the topic, including heuristics, verification, interpretation, and historiography. Most of the data in this study were collected from primary sources in the form of archives, and official documents Department of Public Works and Bandung Municipality Government published in the late 19th century to the first half of the 20th century. The results showed that indigenous people in Bandung, the Sundanese, manage springs and rivers based on local knowledge, harmonizing simple technology with nature and belief. They used* panchuran, *a channel made of bamboo strips, to drain water from the springs. While Europeans initially relied on dug wells for daily water needs in the late 19th Century. However, concerns over epidemics and rapid population growth in the early 20th Century led to more well-planned, professional water management supported by science and technology-based infrastructure. The Bandung municipality government mobilized engineers and scientists to research new water sources and build clean water infrastructure. By the 1930s, they could build artesian wells, waterleiding networks, reservoirs, filtration systems, and clean water public facilities. Bandung municipality government exploited clean water resources that expanded from urban to mountainous areas north of Bandung. The municipality government recognized that clean water resources needed to be explored and capitalized. Two clean water services were available in Bandung: a pipeline service that delivered water directly to households and accessible public facilities. Indigenous people in Kampongs used public facilities, while Europeans used paid pipeline services.*

Keywords*: clean water; waterborne diseases; infrastructure; technology; environmental history; Bandung*

Introduction.

Water is commonly associated as the source of life. The world's greatest civilizations have flourished due to their adjacency to water sources. Water is a common element of Jewish, Christian, and Muslim rituals; water becomes a marker of cleanliness and purity. While water is essential to sustain human life, history has shown that it can lead to devastating consequences. A tragic example of this occurred in 1854 due to the consumption of water contaminated with sewage from a water pipe in Soho, London; as many as 600 individuals lost their lives within one week (Snow, 1857). As a result of this event, the danger of spreading waterborne diseases began to be known. Many casualties were caused by the supply of water polluted with bacteria (*vibrio*

cholerae) did not occur partially but also spread in Europe and North America around the 19th Century (Baldwin, 2009; Briggs, 1961).

Similar conditions have occurred in colonies such as the Dutch East Indies (Indonesia). The spread of cholera outbreaks once hit Java and Madura Island in the early 20th Century (Nasihin, 2021; Tillema-Weehuizen & Tillema, 1919). According to Tuyter (1930), an unhygienic habit and difficult access to clean water caused tropical diseases in the Dutch East Indies, such as hookworms, dysentery, typhoid, and cholera. From the colonial government's perspective, the poor habits of indigenous people in *kampongs* (a hamlet or village) and the threat of plague were thought to hamper the pace of the industry and the economy in cities in the early 20th Century (Jaelani, 2017; Naas, 2007). For this reason, preventive efforts are needed in the form of environmental improvement and the provision of clean water by utilizing urban technologies (Ravesteijn, 2007).

In addition to sewage and flood management facilities, providing clean water infrastructure was an essential element that the municipality government (*gemeente*) was trying to realize in the Dutch East Indies. The availability of clean water can suppress the spread of diarrhea, typhus, dysentery, and cholera in the Dutch East Indies (Van Loghem, 1920; Mom, 1931). Therefore, at the beginning of the 20th Century, municipality governments such as Batavia, Semarang, Surabaya, Medan, and Bandung began to carry out extensive construction for the provision of clean water through artesian wells (*artesische putten*) and pipelines (*waterleiding*) (Paulus, 1917, pp. 62–64). Clean water and infrastructure built by the government were essential to creating a healthier and more prosperous population following ethical politic agendas. The production of clean water infrastructure in the early 20th Century has proven to be a lasting legacy of colonial heritage, particularly in major cities in Indonesia (Kooy & Bakker, 2014; Ravesteijn, 2007).

This study investigates the pioneering efforts of the municipal government in the Dutch East Indies (Indonesia) to establish clean water infrastructure during the late 19th to early 20th centuries, focusing on the local context of Bandung, West Java, Indonesia. The selection of Bandung as the subject of analysis was based on its significance in clean water management during the colonial period, owing to several crucial factors.

First, Bandung is an area that was shaped by the ancient Sunda Mountain caldera. The land lies near four active volcanoes: Tangkuban Parahu, Salak, Galunggung, and Guntur. The geographical characteristics of Bandung are generally associated with fertile land and abundant water sources (Van Bemmelen, 1934). A large number of water sources is also indicated by 295 toponyms of places in Bandung related to water (Kulsum, Sutini, Harijatiwidjaja, Saptarini, & Mulyanah, 2008). Second, Bandung was once designated by Governor General Van Limburg Strirum as a candidate for the Dutch East Indies administrative center to replace Batavia in 1917. Several important departments began to be moved to Bandung in the 1920s, including the Department of Transportation and Waterworks (*Departement van Verkeer en Waterstaats*)

(Roosmalen, 2008). During the early 20th Century, Bandung had institutions, such as the Bandung Technical High School (*Technische Hoogeschool te Bandoeng*), the Geological Laboratorium (*Geologisch Laboratory*), and the Pasteur Institute, which facilitated research and innovation in the field of clean water resources.

Given these factors, it is possible that Bandung had a well-planned clean water infrastructure and governance during the early 20th Century. This study validates this hypothesis by examining Bandung's clean water management. The study sheds light on the pattern of clean water management in one of the prominent cities in the Dutch East Indies, providing insights for future studies.

The study of clean water is not new in the historiography of the colonial period, especially in Southeast Asia and Indonesia. Yeoh (1993) conducted a similar study, discussing Singapore's sanitation reform and clean water networks. Taylor (2013) discusses the concept of cleanliness and the practice of bathing in the daily livelihoods of the Dutch and indigenous people in the Dutch East Indies. Kooy and Bakker (2014) explore Batavia's piped water network through a postcolonial lens, seeing piped water as a colonial heritage. Andaya (2018) discusses the various approaches that can be used to study water in the Southeast Asian region. In a more local scope, research has also been carried out on improving the political system and clean water governance in Surabaya (Achdian, 2020), sanitation problems in Medan (Affandi, Agustono, & Zuska, 2022), and the construction of water pipelines in the context of the historical trajectory of modernization in Yogyakarta, Surakarta, Surabaya, and Batavia in the early 20th Century (Primaditya, 2022).

A previous study that is quite intersected with the locus of this study is the result of Budiman's (2022), which discusses the *Development of Sanitation and Hygiene Infrastructure in Bandung in the Early 20th Century*. The study discusses clean water sources, household waste management, and waste management in the context of hygiene. However, the study has only examined clean water sources and their distribution. That study has no depth discussion about exploration, technology, and clean water management. For this reason, this study was to deepen the study conducted by Budiman (2022) through the lens of anthropogenic changes in the water system proposed by Tvedt (2010). Anthropogenic changes in this study are the modification or management of physical water units by human communities, such as the construction of dams, canals, reservoirs, ponds, and wells that can affect the physical aspects of water and the culture of local communities (Tvedt, 2010). The water in this study does not include urban drainage management, flooding problems, or irrigation water in an agricultural context. This study contains water sources in the freshwater domain: river water, groundwater, and springs used for drinking, bathing, and daily household needs.

Research method.

This study uses the historical method to reconstruct past events. The historical method consists of four steps: heuristics, verification, interpretation, and

historiography (Gottschalk, 1969). At the heuristic stage, we collected primary textual sources, including the annual report of the Department of Public Works (*Burgerlijke Openbare Werken*) from the end of the 19th Century to the first decade of the 20th Century, the report on the condition of the Municipality of Bandung (*Verslag van den Toestand der* Gemeente Bandoeng) 1906–1918, the piped water report of the Bandung Municipality (*Waterleiding Rapport Gemeente Bandoeng*) 1924, hygienes brochure of Bandung and its surroundings (*De Hygiene in Bandoeng en omstreken*), civil engineering journals (De *Ingenieur, Locale Techniek*), newspapers and magazines (*Algemeen Indisch Dagblad, Bataviaasch Nieuwsblad, De Locomotief, Het nieuws van den dag voor Nederlandsch-Indië, Mooi Bandoeng*), and encyclopedia of the Dutch East Indies (*Encyclopedie van Netherland Indie*). In addition to primary sources from the 19th and 20th centuries, we use secondary sources, including dissertations and up-to-date journal articles.

After the collection of sources, we conduct the criticism stage, which is the stage of verifying the sources. After verification of the sources, the step carried out is interpretation. A thorough reading of the textual source is required to obtain an interpretive examination of social phenomena (*verstehen*). At this stage, the reading process is carried out by bringing perspective on anthropogenic changes in the approach of the water system. The final step is historiography; The facts of the reading are then arranged systematically based on a frame of mind and time sequence to present a complete historical narrative.

Result and discussion.

Bandung, located in the hinterland of West Java, can be classified as a mountainous region with an elevation of 2,300 feet above sea level. This area was surrounded by mountains, nourished by rivers, and boasted fertile soil (Coolsma, 1879; Forbes, 1885). Bandung's basin area was previously a prehistoric lake that desiccated, resulting in the region being endowed with numerous water sources and marshy zones (Forbes, 1885, p. 107; Hardjasaputra, 2002). As one of the important cities in West Java, Bandung is traversed by two major rivers, Citarum and Cikapundung. The city, which Regent Wiranatakusumah II founded in 1810, is also traversed by small rivers such as the Ciguriang River on the west side and the Cikawao River on the east side (Kunto, 1986; Yusandi, 2022). Four volcanoes surround Bandung: Tangkuban Parahu, Salak, Galunggung, and Guntur (Van Bemmelen, 1934). Foreign travelers who visited Bandung in the past were often captivated by the region's natural splendor, which presented an idyllic vision of the Dutch East Indies in the form of expansive plantations, picturesque mountains, cascading waterfalls, and refreshingly cool air (Reitsma & Hoogland, 1927).

Significance of water in the establishment of Bandung.

The precursor to the city was established in the southwest of the Cikapundung River and comprised the regent's house, pavilion, square, and mosque, which were built

near the Post Road (*De Groote Postweg*). During its early years, Bandung was a forested area that gradually developed into a village in the hinterland of West Java. North of Post Road, several old *kampongs* (a hamlet or villages) stood: Balubur, Cikalintu, Gadog, Dago, Gegerkalong Girang, and Babakan Bogor (Hardjasaputra, 2002; Kunto, 1986).

The selection of the locations for the old *kampongs* in the Bandung area was heavily influenced by a mythic-spiritual element that prioritized water as a primary consideration. Furthermore, the positioning of the *kampongs* and the city center (*alun-alun*) was guided by the principle of "*garuda ngupluk, tanah hade, bahe ngaler-ngetan, deukeut pangguyangan badak putih*" (the location of land resembling the flapping wings of the mythical bird Garuda, fertile soil, sloping towards the northeast, and adjacent to the place where the white rhinoceros wallows) (Affandie, 1969, p. 6; Kunto, 1986, p. 397). The term "*pangguyangan badak putih*" (the place where the white rhinoceros wallows) is an analogy to a place rich in sources of water.

According to Kunto (1986) and Tillema (1915), it can be seen those old *kampongs* in Bandung were located close to springs, such as *Kampong* Cikalintu, which is adjacent to the "*Pancuran Tujuh*" spring in Cikendi, *kampong* Bogor was adjacent to Ciguriang spring. *Kampong* Balubur was adjacent to Balubur Spring. The city center (*alun-alun*) was close to the water source known as Bandung Well (Tillema, 1915). The origin of Bandung Well is mythologized as a source of gushing water because of the stick that Wiranatakusumah II stuck when he visited the location of the precursor of the city (Akhmad, 2021).

The Sundanese people in Priangan, West Java, were accustomed to living amid nature abundant with water. They rarely experience a lack of water for drinking and bathing; almost every house has its pond (Coolsma, 1879). The main livelihood of the Sundanes community, including the people of Bandung, was cultivating fields and rice fields that required a lot of water supply (Drewes, 2013).

Most of the inhabitants of Bandung in the early 19th Century were *cacah*; commoners who worked to cultivate agricultural land, raise livestock, and make various tools (Coolsma, 1879; Hardjasaputra, 2002). They lived simply in a stilt house (*imah tjeblok*) with its simple sanitation; utilizing the water of the Cikapundung River (Kunto, 1986). This kind of population was characteristic of the rural population.

According to Hardjasaputra (2002, p. 53), Bandung in 1825 was more like a village with a traditional order characterized by town squares, pavilions, a mosque, and a hall known as *Bale Bandung*. The road conditions were covered with gravel stones and muddy in case of rain. There were few permanent buildings, such as residential lodges, military barracks, and inns (Hardjasaputra, 2002, p. 57). Until 1846 the city's growth was slow. The number of inhabitants was not too much: 11,000 Indigenous, 13 Chinese, 30 Arabs, and 9 Europeans (Himpoenan Soedara, 1936, p. 5).

Bandung's growth accelerated in 1862 when the Priangan (West Java) Governor's office was relocated from Cianjur to Bandung. The city's rapid development was also driven by several other factors, including the construction of the western railway line,

the establishment of railway workshops, and the establishment of the War Department in the 1880s (Drewes, 2013). The enactment of the Agrarian Law in 1870 caused many European business people to arrive and open companies in Bandung. European employees and professionals came to Bandung to build a new life. At the same time, there was a process of moving indigenous residents from villages to find jobs and live in cities (Reerink, 2015). By 1890, the population was already much larger: 16,656 Indigenous, 991 Arab, and Chinese, and 467 European (Himpoenan Soedara, 1936, p. 6).

By the end of the 19th Century, Bandung had transformed into a complex colonial city. The Priangan Governor had the power to determine urban design policies; the indigenous group had its local government, while settlements were organically segmented by race and ethnicity (Hardjasaputra, 2002; Naas, 2007). The indigenous people tended to build *kampongs* scattered to the south and east of the Post Road, and the Chinese and Arabs settled around the markets to the west of the city. The Europeans built settlements and centers of activity next to the Post Road, leading to the Lembang plateau. At this point, the formation of the city raises problems: adequate clean water according to population growth and efforts to overcome the outbreak that was prevalent in the Dutch East Indies in the 19th Century (Jaelani, 2017).

Clean water sources in the 19th century.

For indigenous residents, especially the Sundanese people, clean water sources were obtained and managed based on local knowledge (Lombard, 1996). The spring (*seke*) was sacred and associated with the spirit, gods, and ancestors (Hoogland, 1937; Wessing, 1988). This spring that was considered sacred can be found in folklore, such as the story of Nyi Mas Katrimanik. This spring that was regarded as sacred also can be found in the lore of the Wiranatakusumah II stick that can spouts spring water; and the well-waiting gho*st* (*jurig*) in the folklore of *Roesdi jeung Misnem* (Akhmad, 2021; Deenik & Djajadiredja, 1930; Hoogland, 1937). Sumardjo (2019), in his research on Sundanese cultural artifacts, mentions that spring water is symbolized as something sacred; it is far upstream, close to the "upper world," close to the gods and spirits of the ancestors (Sumardjo, 2019).

The sacred water sources can be related to prohibition forests (*hutan larangan*), where springs and various vegetation can be sustained without disrupting human hands (Prestasi & Kim, 2020; Wessing, 1988). The sacred of these springs allows for clean water sources and circular water management. Upstream is a clean water source; in villages, water is used for rice fields. While downstream, water is used for sewage and fish ponds. Nevertheless, this pattern is applied in rural environments that are still close to nature, not for the type of urban environment that is more complicated in the layout of the settlement.

According to the *Encyclopaedie van Nederlandsch Indie*, people living in mountainous areas like Bandung and the west Java hinterland—the Sundanese--use natural springs from rocks to access clean and fresh water (Lith, Spaan, & Fokkens,

1900b). The indigenous use bamboo to collect water from the seepage between the rocks. The bamboo was placed at an angle to allow the water to flow slowly and steadily onto it. This simple technology was called *pantjoeran* (Lith, Spaan, & Fokkens, 1900b, p. 471). In the Sundanese dictionary, the term *pantjoeran* or *panchuran* refers to a fixed and unmovable spout, channel, gutter, or bamboo piece used for directing water and even as a spout for bathing purposes. This word's etymology can be traced back to "*chur*," meaning to flow out (Rigg, 1862, p. 342).

Figure 1. KITLV 11902, Two women washed clothes near the Cikendi spring, Bandung. Water from the spring flows through *panchurans* (KITLV, 1920a).

The Sundanese collect water from the *panchuran* and filter it using a cone-shaped tuff vessel suspended within a wooden frame. The filtered water drips into a *tempayan* (crockpot), where it is collected. (Lith, Spaan, & Fokkens, 1900b). If the crockpot is left outside the house at night, it can help to cool down the collected water (Lith, Spaan & Fokkens, 1900b). In Bandung, the Sundanese refer to the crockpot as "kendi." Interestingly, the word "kendi" is also associated with a toponym called "Cikendi," one of the springs in the northern part of Bandung (Van Bemmelen, 1934; Gemeente Bandoeng, 1924). The name "Cikendi" originated from the indigenous practice of using a *kendi* to collect water from the *panchuran*.

Panchuran was commonly used to drain springs in the 19th Century (Kolff, 1880; Lith, Spaan, & Fokkens, 1900b). In addition to obtaining clean water from *panchuran*, the indigenous inhabitants utilized the clear waters of the Cikapundung River for their daily needs, including bathing, washing clothes, and even defecating (Kunto, 1986;

Tillema, 1915). This habit of using surface water became one of the reasons for the spread of cholera and typhoid in the Dutch East Indies (Van Loghem, 1920; Tuyter, 1930).

Unlike some regions in Java, such as Pasuruan, Tegal, Banyumas, Madura, Surabaya, Batavia, and Tangerang, Bandung was never afflicted by a significant cholera outbreak during the 19th Century (De Volksziekten in Nederlandsch Indie, 1877). Based on news in the *Haagsche Courant*, cholera in Bandung occurred in 1891 and killed a resident named Heitjing (Baranoerie, 1891). Likely, cholera cases in Bandung at the end of the 19th Century were sporadic and isolated. That condition can be attributed to Bandung's access to multiple sources of clean water from springs and surface water, which were not contaminated with sewage, thus minimizing the risk of cholera outbreaks (Tillema, 1915). Moreover, by the end of the 19th Century, the indigenous population had already adopted boiling water (known as "*njaneut cai*") to eliminate bacteria, further contributing to preventing waterborne diseases like cholera (Anoniem, 1894; Coolsma, 1879).

Despite the existing preventive measures, access to adequate clean water remained a pressing issue as the population grew and the city became a more modernized urban center. European settlers in the Dutch East Indies during the 19th Century were knowledgeable about water hygiene standards. They preferred to use water from a well instead of a river. However, the use of well water was limited to individual households. The water quality in these wells was highly dependent on the soil condition and the depth of the well, which meant that not all soils could provide a safe source of drinking water (Bergmans, 1909, p. 89).

In 1898, the Drinking Water Supply Division, which operated under the Department of Waterworks (*Waterstaatswerken*), initiated efforts to excavate artesian wells in Bandung by the Government Regulation No.4 dated May 10, 1883 (Burgerlijke Openbare Werken, 1902). The location for the excavation of the artesian well was selected by the Director of Education, Religion, and Industry in consultation with Governor Priangan, West Java (De Locomotief, 1898).

Artesian wells were somewhat different from ordinary dug wells that were used individually. Governor-General permission was required for digging artesian wells deeper than 35 meters (Lith, Spaan, & Fokkens, 1900, p. 46). Artesian wells can reach depths of over 700 meters, providing clean water less prone to bacterial contamination. The water from artesian wells was usually more abundant in areas around volcanoes. The Mining Department carried out geological surveys of artesian water sources in the Dutch East Indies. The drilling methods used were twist-flushing and ramming-flushing (Paulus, 1917).

Artesian wells were excavated in five locations in Bandung: Tegalega Indigenous School (72 meters deep, 400 liters/minute flow rate), a well near the Bandung Post Office (67.75 meters deep, 715 liters/minute flow rate), near the house of the Priangan Governor (61.2 meters deep, 460 liters/minute flow rate), north of the Chinese Temple, and at the Cimahi Military Camp (Burgerlijke Openbare Werken, 1898, p. 134).

Efforts to explore new water sources continue by the Waterworks Department. Still, excavations often experience technical obstacles, such as drilling hampered by large rocks resulting in personnel injuries (Burgerlijke Openbare Werken, 1899). The process of exploring water sources in Bandung faces not only technical challenges but also financial constraints. As the region has not yet achieved autonomy, the available funding depends solely on the central government of the Dutch East Indies. Investigations into water hardness levels often require the participation of private parties, such as researchers from the Quinine Bandung Company (Burgerlijke Openbare Werken, 1902). Despite limited funding, the Waterworks Department successfully discovered five artesian wells by 1901. These wells included those in Tegalega (250 liters/minute), the Post Office (660 liters/minute), the Priangan Governor's house (670 liters/minute), Citepus (1550 liters/minute), and Oud Medika (2700 liters/minute) (Burgerlijke Openbare Werken, 1901). The clean water from these five artesian wells was made available to the residents of Bandung for free (Algemeen Indisch Dagblad, 1931c).

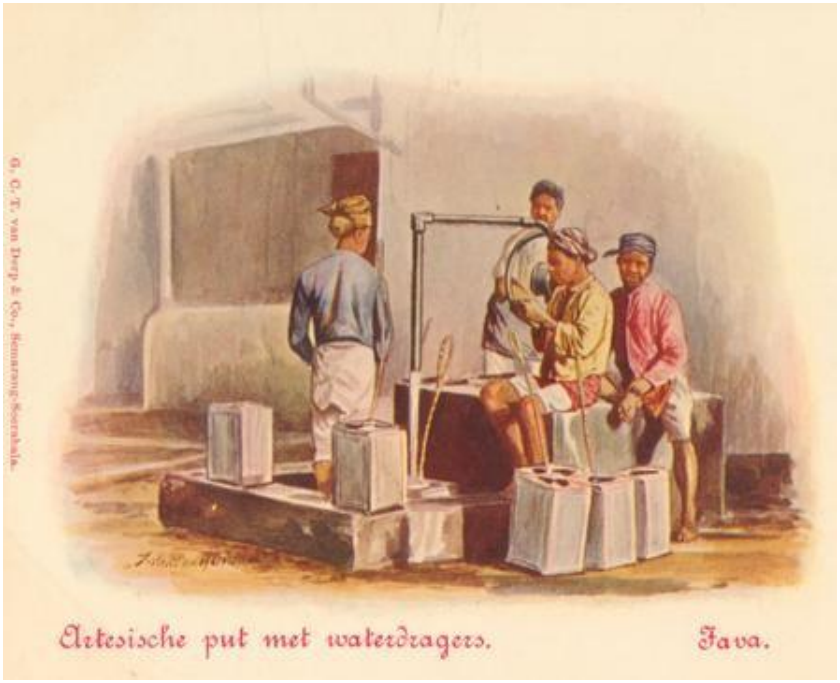

Figure 2. KITLV 110991, Illustration of a *tukang angkut air* in Java in 1900 (Van der Heyden, 1900).

European residents in Bandung obtained their clean water supply from the artesian wells with a *tukang angkut air* (water carrier) that delivered water to their households. Unfortunately, these *tukang angkut air* typically used old oil cans to transport the water, which posed a significant risk to the cleanliness of the water supply (Figure 2). Each *tukang angkut air* could transport two cans of water (36 liters total), with each liter being sold at a price ranging from 0.15 to 0.25 guilders per liter (Algemeen Indisch

Dagblad, 1931c; Van der Heyden, 1900). Meanwhile, for indigenous residents, clean water sources from artesian wells do not entirely change the habit of still using the river and spring for bathing and washing clothes (Tillema, 1915).

Clean water solutions in the early 20th century.

At the beginning of the 20th Century, Bandung became more autonomous and modern. In 1906 the status of Bandung changed to the *Gemeente* (municipality), with the management of the city in the hands of a city council dominated by Europeans (Himpoenan Soedara, 1936). Bandung grew rapidly with rail transportation, shopping centers, hotels, schools, and new settlements for Europeans (Hardjasaputra, 2002; Kunto, 1986; Voskuil, 2017). By 1906, the population of Bandung consisted of 2199 Europeans, 3799 Foreign Easterners, and 41393 indigenous residents. (Himpoenan Soedara, 1936). As was typical in colonial cities, the development and management of urban infrastructure, including hygiene and clean water supply, were often determined according to a relatively small group of Europeans' interests (Bandoeng, 1929). On the other hand, indigenous people in *Kampongs* have their standard of living and local government, which is often difficult for the municipality to intervene directly (Reerink, 2015).

Indigenous settlements' low cleanliness level became a real threat in the early 20th Century (Bandoeng, 1929; Tillema, 1915). Cholera cases frequently occur in *kampongs*, as reported in *Het nieuws van den dag voor Nederlandsch-Indië* (Cholera te Bandoeng, 1913). Cholera cases have been found in several *kampongs:* Tegalega, Citepus, Regol, Cikakak, Cibeunying, Cisondari, Ujungberung, and Cipatat. Some cases of cholera cause fatalities, and others only cause sufferers to be taken to the hospital (Cholera te Bandoeng, 1913). Due to the frequent occurrence of residents affected by cholera, *Gemeente* Bandung formed cholera brigades in charge of providing health counseling to residents. However, due to rumors of kidnapping and not establishing good communication with the indigenous, the arrival of the cholera brigade to *Kampong* Kebonjeruk caused clashes with indigenous residents and caused the death of two policemen (Cholera-Opstootje te Bandoeng, 1909; Kunto, 1996, p. 52).

Since the incident, *Gemeente* Bandung began to take more preventive and severe efforts to prevent the spread of cholera in Bandung. One of the steps was to realize access to clean water for the community. In 1910, *Gemeente* Bandung poured funds of 85,000 guilders to build a clean water pipeline network (*waterleiding*) in the East Bandung area. The pipeline was connected to the artesian well in Oud Merdika and the new artesian well in *Kampong* Balubur (Bandoeng, 1929). The water pipeline was designed by a civil engineering agency called Nierstrasz (Tillema, 1915, p. 103). Construction of the first water pipeline was completed in 1911, and the pipeline network was used by 100 customers (Algemeen Indisch Dagblad, 1931c). In 1912 the construction of pipelines continued with 200 pipeline connections to customers'

households. The profit in that year reached 4200 guilders (Gemeente Bandoeng, 1919, p. 28).

In 1913, the *Gemeente* Bandung invested 150,000 guilders in expanding the pipeline network, which extended to the West Bandung area (Bandoeng, 1929). Until 1915, Bandung had seven artesian wells in Dago, Oud Merdika, Pasirkaliki, Citepus, Cicendo, Balubur, and old wells near Post Road (Tillema, 1915, p. 103). These seven artesian wells were Bandung's primary source of clean water. However, the existing pipeline network can only cover 550 customers, including hotels, markets, and schools. Not all available pipelines were connected to artesian wells. Few artesian wells have pipelines, so most residents must use *tukang angkut air* (water carrier) services.

Meanwhile, indigenous residents with low economic ability must collect water directly from available artesian wells, rivers, or natural springs in the highlands of Bandung. Sometimes, indigenous residents use leaking water pipes to get clean water, even bathing at the location of the leaky pipe (Tillema, 1915). This condition illustrates the uneven access to clean water, so *Gemeente* Bandung took the initiative to provide additional clean water facilities for indigenous residents, which include 14 public washing stations (figure 3), bathrooms, and public toilets in *kampongs* with proper hygiene and drainage standards (Departement van Binnenlandsch Bestuur, 1929, p. 97; Tillema, 1915). *Gemeente* Bandung also provides 72 public drinking water taps and 333 hydrants to anticipate *kampong* fires (Gemeente Bandoeng, 1919, p. 30).

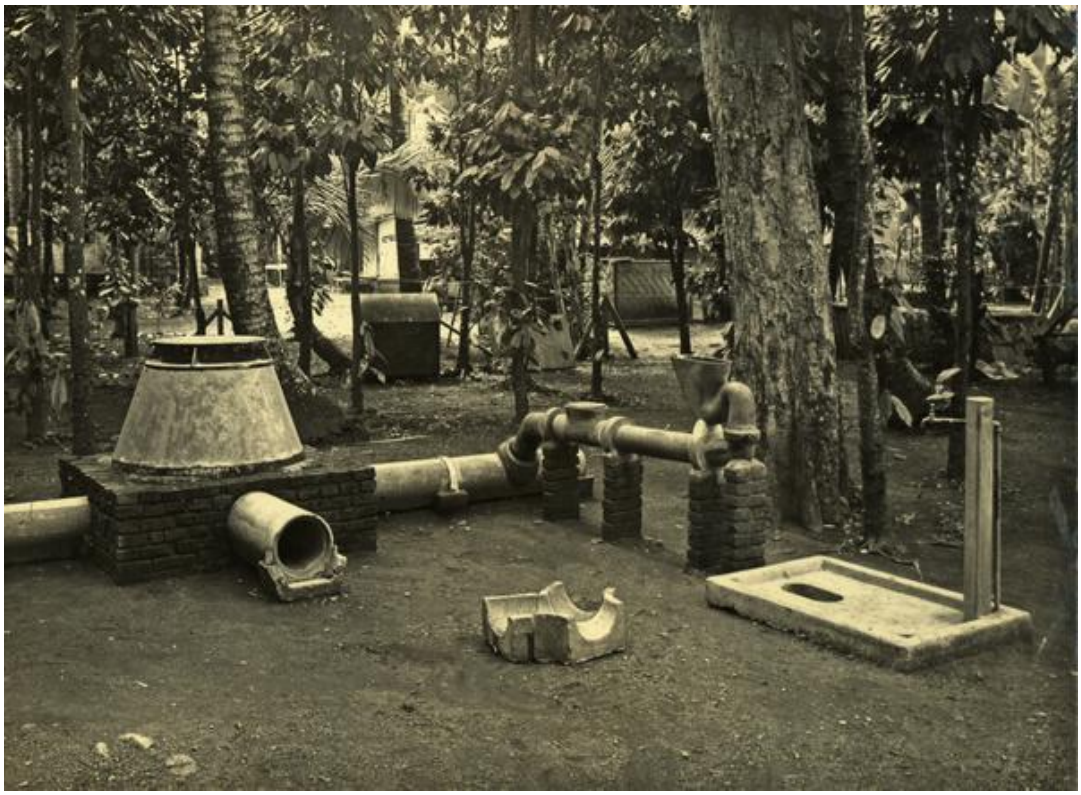

Figure 3. KITLV 157053, Public washing station in *kampong* (KITLV, 1929).

The construction of pipelines continues to be carried out in line with the expansion of residential areas in the north of Bandung. According to a 1916 *Gemeente* report, the main water pipeline network was 80 km (Gemeente Bandoeng, 1919, p. 30). By 1918, pipelines had been connected to 2081 locations, including settlements (Gemeente Bandoeng, 1919, p. 30). Bandung Public Works Departement began to explore the sources of springs in Cibadak (figure 4) and Cikendi springs, including water reservoirs in the two springs in 1921. Cikendi has a water flow of 240 liters/minute, and Cibadak has a water flow of 2,340 liters/minute (Gemeente Bandoeng, 1924). Clean water infrastructure was added by the construction of 3 reservoir buildings in Lembang Road, Cidadap, and Sumatra Street (figure 5) (Bandoeng, 1929).

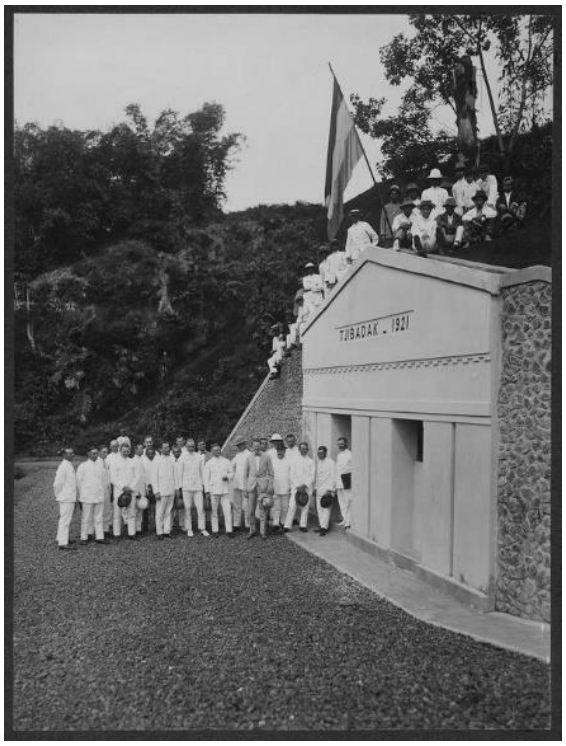

Figure 4. KITLV 11931, Opening of Cibadak Reservoir (KITLV, 1921).

Figure 5. KITLV 11898, Reservoir at Sumatera Street (KITLV, 1920b).

Although the pipeline network continues to expand, the water supply depends only on seven wells and two main springs of the city (Walland, 1922, p. 961). This condition can cause a clean water crisis during the dry season. Moreover, water consumption also increased in line with the rapid population growth from 1915 to 1920. Furthermore, water flow in some of the artesian wells began to decrease. To prepare for these circumstances, *Gemeente* Bandung established a commission in 1921 called the *Waterleiding Commissie* to investigate new water sources. The commission comprised hydrologists and civil engineers, including Ir. C. A. De Jongh, from the Mining Department (*Lands Mijndiensten*) (Walland, 1922, p. 961). According to the commission's calculations, Bandung needs to increase the water flow from

120 liters/second to 270 liters/second. This calculation was based on the projected population until 1940, estimated to reach 194,000 people with a daily water requirement of 23,400 m^3 (Walland, 1922, p. 962). Such a large daily water requirement can be achieved if the water flow in Bandung reaches 270 liters/second. To achieve this goal, *Waterleiding Commissie* has identified points of springs to explore in North Bandung: from Dago to around Tangkuban Parahu Mountain (Van Bemmelen, 1934; Gemeente Bandoeng, 1924). The new water source that has been successfully discovered and qualified based on the *Waterleiding Commissie* assessment is listed in Table 1.

Table 1. Recommended springs by *Waterleiding Commissie* (Gemeente Bandoeng, 1924, p. 3).

No	spring	Estimated minimal water flow	Minimal water flow measured in 1923
1	Cigerohong	10 liter/second	-
2	Citelaga I	13 liter/second	1,2 liter/second
3	Cicariuk	30 liter/second	22 liter/second
4	Cisalada I	25 liter/second	12 liter/second
5	Cisalada II		7 liter/second
6	Cipancak	15 liter/second	--
7	Cipulus	--	14,5 liter/second

In addition to the seven main springs recommended, the *Waterleiding Commissie* also successfully identified and researched 18 alternative springs that could be explored. *Waterleiding Commissie* divides all spring points into four complexes: complex I on Lembang Road, complex II in Sukawana, complex III in Ciater, and Complex IV in the hills of northern Bandung (Gemeente Bandoeng, 1924, p. 6). Based on these recommendations, *Gemeente* Public Works Departement was only able to follow up with the exploration of Cisalada I and Cisalada II, Cicariuk, Ciliang, and Ciwangun spring, including the construction of pipelines connecting the five springs in 1925 and 1926 (Bandoeng, 1929; Thijsse, 1935, p. 43). The last spring explored was Cigentur Spring in 1934. Referring to the *Bandoeng en de Hygiene* brochure compiled by *Gemeente Bandoeng* (1929), the water pipelines successfully built until 1929 had a total length of 130 km, with 9 km of pipelines connected to reservoirs.

Until 1934, clean water services in Bandung have several important infrastructures: artesian wells, springs, reservoirs, manifold pipelines, Mannesmann pipes, and public facilities for clean water providers such as hydrants, drinking water

taps, toilets, bathrooms, and public washing. Public toilets, bathrooms, and washes are usually built in *kampongs* (Kampong Toestanden, 1925).

Table 2. Clean Water Service Infrastructure in Bandung in the 1930s*.

Artesian Well	**Spring**	**Reservoir**	**public facilities**	**Pipelines**
Dago	Cikendi	Cikendi	70 public toilet	The 139 km long Manifold and Mannesmann pipelines
Oud Merdika,	Cibadak	Cibadak	70 public bathroom	
Pasirkaliki	Cisalada I	Cisalada I	70 public laundering	
Citepus	Cisalada II	Cisalada II	72 drinking water tap	
Cicendo	Cicariuk	Cicariuk	333 hydrant	
Balubur	Ciliang	Ciliang		
Post Road	Ciwangun	Ciwangaun		
	Cigentur	Lembang Road		
		Sumatera Street		

*Source: Author's reconstruction based on data in *Waterleidingrapport* (Gemeente Bandoeng, 1924), brochure *Bandoeng en de Hygiene* (Bandoeng, 1929), and articles written by Thijsse (1935) about waterways and decarbonization installations in Bandung.

Distribution and technology.

In the early 20th Century, Bandung's piped water services were made possible due to the appropriate application of science and technology by the Bandung Public Works Department. The department utilized hydrological, geological, hydraulic engineering, and bacteriology to run the water services. This scientific approach was applied to the natural potential of Bandung's mountainous landscape, rich in water resources. To supply water to urban areas with flat ground surfaces, the Public Works Department utilized water from deep underground sources, such as artesian wells (Bergmans, 1909; Lith, Spaan, & Fokkens, 1900a). Water from artesian wells avoids several harmful pathogens, but artesian water sometimes still contains manganese compounds (non-pathogenic) (Thijsse, 1935). Water from artesian wells in the middle of the city was collected in reservoirs and then flowed to settlements using manifold pipelines

(Gemeente Bandoeng, 1924). To distribute water to areas with slightly higher surfaces, pump technology was utilized through manifold pipes. This simple system was effective when the population of Bandung was few between 1910 and 1915. As the population grew, the artesian well became insufficient to meet the increasing demand. Engineers and geologists then began to search for alternative water sources from the highlands of Bandung.

Water sources in the form of springs in the highlands of Bandung were accommodated in reservoirs. It is on these reservoirs that engineers apply limestone filtration and aeration methods to produce cleaner water; avoid carbonic, carbonate, and bicarbonate acids (Thijsse, 1935). The limestone filtration method was a process of purifying water by using limestone as a filtering medium. Limestone aids in reducing the levels of heavy metals and other chemical elements, increase the water's pH level, and make it cleaner and safe for consumption. The aeration method was a way of water treatment that utilized additional oxygen to help remove contaminants and harmful materials from the water. The limestone filtration method was applied in Cikendi, Cibadak, Ciwangun, and Ciliang reservoirs. Meanwhile, the aeration method was applied in the Cisalada I, Cisalada II, and Cicariuk reservoirs (Thijsse, 1935, p. 44). Water purification methods are applied to reservoirs, resulting in a combination of complex water treatment technology with magnificent building architecture (figure 4 and 5). According to Thijsse (1935, p. 45), applying limestone filtration and aeration technology to the reservoir costs 50,000 guilders with an annual maintenance cost of 3000 guilders.

The water distribution process in Bandung (Figure 6) benefits from the city's land contour, which slopes southward. The springs on the plateau north of Bandung can easily flow south by following the law of gravity. The water flow from the north was then distributed to the city using the Mannesmann pipe (Gemeente Bandoeng, 1924). To distribute water evenly throughout the city, the Public Works Department applies hydraulics techniques. Based on the principle of hydraulics, Bandung was divided into three zones: high zone, flat zone, and low zone. Each zone has a separate reservoir on a more elevated surface, making water distribution easier.

Water was channeled from each reservoir in the three zones to settlements, schools, hotels, factories, markets, and companies. To facilitate water flow control from each reservoir, the Public Works Department began using centralized electronic water flow measuring instruments in 1931 (Rietschoten, 1932). Such water current gauges are connected to the entire reservoir by electric power. With these gauges, the Bandung Water Company can easily monitor water flow per day (Rietschoten, 1932).

Clean water management and regulation.

The institution directly responsible for the clean water supply in Bandung was the Bandung Public Works Department (*Gemeente Werken*). In 1914, Heetjans was appointed Director of the Bandung Public Works Department and co-headed the

construction process of the Bandung clean water pipeline (Tillema, 1915, p. 103). During Heetjans' reign (1914-1928), much of the city's infrastructure was built, including clean water service infrastructure. In 1922, The Public Works Department established a special division responsible for providing clean water, namely the Public Works and Water Supply Division (*Publieke Werken en Waterleiding*). G. van Galen Last initially headed the division, then in 1924, it was replaced by Poldervaart (Algemeen Indisch Dagblad, 1931b).

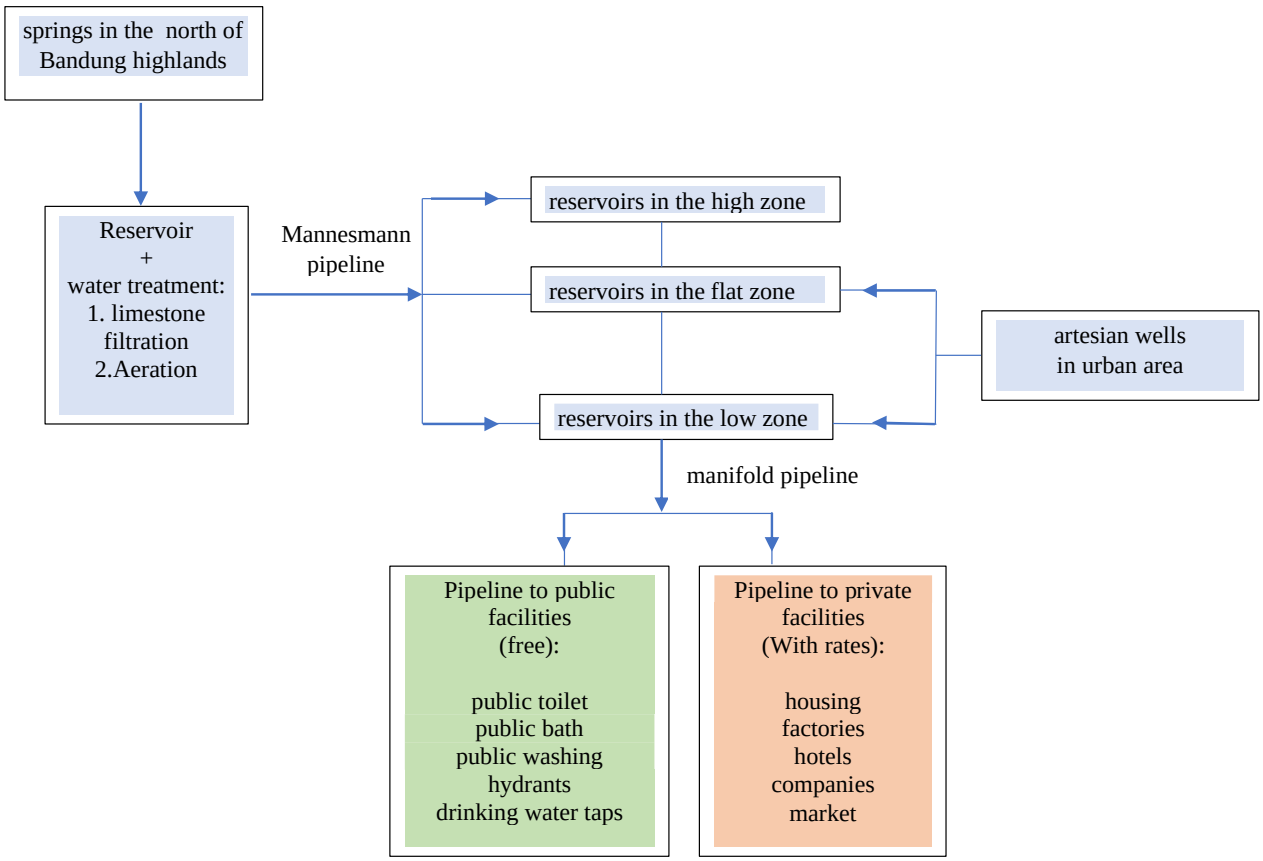

Figure 6. Water distribution scheme in Bandung in the 1930s. Source: reconstruction based on *Bandoeng en de Hygiene* (Bandoeng, 1929) and Thijsse's article on waterways and decarbonization installations in Bandung (1935).

The Bandung Public Works Department provides clean water. It is also assisted by other institutions such as the Mining Department (*Mijnwezen*), the Pasteur Institute, and the Bandung Technical High School (*Technische Hoogeschool*). Engineers from the Mining Department, such as Ir. C. A. de Jongh, worked in the early stages of geological surveys to determine water sources that could be explored (Gemeente Bandoeng, 1924). Public Works Department then follows up by excavating and building infrastructure that supports water availability. The infrastructure includes wells, reservoirs, water treatment units, and water distribution pipelines. Meanwhile, bacteria experts from the Pasteur Institute were tasked with checking bacterial levels in water sources found in Bandung. Once a water source was available, bacteriologists

checked the water once a month to make sure water was safe for consumption (Bandoeng, 1929, p. 31).

For research and water purification efforts, The Bandung Public Works Department also involved researchers from the Water Purification Laboratory (*Laboratorium van Waterzuivering*) in Manggarai, Batavia (Thijsse, 1934). Engineers who work at *Technische Hoogeschool* Bandung, such as Ir. Jac. P. Thijsse Jr. and Dr. C. P. 's Mom conduct research and development related to the water supply. C. P.'s Mom researched the relationship between drinking water, soil pollution, and intestinal diseases (gastroenteritis) (Mom, 1931). Thijsse Jr. conducts development and research on types of water purification technology suitable for water sources in North Bandung (Thijsse, 1935).

The Bandung Water Company (*Gemeentelijk Waterleiding Bedrijf*) was responsible for maintaining clean water infrastructure, distributing water to residents, collecting clean water customer dues, and managing the budget (Algemeen Indisch Dagblad, 1931c). The division of roles and functions of these various institutions was only able to run well in the second decade of the twentieth Century when *Gemeente* Bandung was more established in terms of finance and managerial (Algemeen Indisch Dagblad, 1931c; Bandoeng, 1929).

Well-planned clean water management based on the legal regulation was only formed on April 28, 1911, through the Water Ordinance for Bandung (Gemeente Bandoeng, 1921, p. 154). The regulation, continuously updated until 1916, explained that water supplies obtained from public facilities could be used freely and free of charge. Meanwhile, those who want water pipe services directly to households, shops, offices, and companies must register with the Bandung Public Works and Water Supply Division. In the Water Ordinance, there are detailed rules on water usage tariffs. Customers were charged a rate based on the building's monthly rental figures. For example, for a building whose monthly rental value was between 5–10 guilders, a fee of 0.5 guilders was charged per use of 1 m^3 of water. The higher the rental value of the building, the higher the price of water for every 1 m^3 (Gemeente Bandoeng, 1921).

This condition illustrates that the Bandung municipality government has been able to capitalize on the water resources they manage. Bandung, in the early 20th Century, saw the establishment of many companies, hotels, and government employee settlements that required a lot of water supply. Therefore, the practice of water management became profitable. In 1930, Bandung Water Company profited 650,000 guilders from 12,250 customers (Algemeen Indisch Dagblad, 1931c). Bandung Water Company's profits continued from 1916 to 1930 (Algemeen Indisch Dagblad, 1931c). In 1931, Bandung Water Company invested 1,850,000 guilders in realizing a water supply that could cover 50% of Bandung's population (Algemeen Indisch Dagblad, 1931c).

The regulation of clean water and the capitalization of clean water sources shows the segmentation of water access in Bandung in the early 20th Century. The provision of water pipelines to houses at certain costs and administrative rules may only be

fulfilled by the upper middle class, such as European employees, business people, and government employees. Clean water services support water-based companies like mineral water factories, swimming pools, and hotels with hot water facilities in Bandung by providing a large water supply (Algemeen Indisch Dagblad, 1931a).

For economically disadvantaged groups, such as indigenous residents in a *kampong*, access to clean water was only possible through shared public facilities, including water taps, toilets, washing areas, and bathrooms (Bandoeng, 1929; Kampong Toestanden, 1925). To get clean water, they must walk to available public facilities. This practice was common in the Dutch East Indies. Indigenous people were accustomed to bathing and washing clothes in public areas such as rivers and public washing (Taylor, 2013). This condition is reflected in the folklore of *Roesdi jeung Misnem.* In the folklore, it is told about a boy named Ramlan and Rusdi who had to walk from *kampong* to the town square to take an afternoon bath at the location of an artesian well (Deenik & Djajadiredja, 1930, p. 96). This condition is in contrast to Europeans who can access water in their own houses, behind closed walls, and privately (Taylor, 2013). Providing clean water pipes directly to houses was a privilege for economically established groups.

Conclusions.

This study reveals that in the 19th Century, the people of Bandung, West Java, Dutch East Indies (Indonesia) relied on natural water sources without state intervention. The Indigenous population uses water from rivers and springs, utilizes simple technologies such as *panchuran.* They harmonize local knowledge with nature and beliefs. At the same time, Europeans relied on dug wells. The Dutch East Indies government became involved in clean water exploration begin 1898 through the Department of Waterworks, which initiated the excavation of artesian wells.

As Bandung grew more crowded in the early 20th century and disease outbreaks like cholera became prevalent, the Bandung Municipality Government recognized the need to control and manage clean water sources. Between 1911 and the 1930s, they embarked on infrastructure development based on science and technology to enable well-planned and profitable clean water management. At this point, technology becomes a medium that helps the Bandung Municipality Government to control water sources. The Bandung Municipality Government explored clean water sources in the urban areas and the mountainous regions north of Bandung. However, clean water services were only partially free for residents. Wealthier European residents used paid, directly accessible piped water services from their households. In contrast, indigenous residents in *kampongs* had to rely on public facilities far from their homes.

This study suggests further investigation to assess the environmental impact of water source exploration during the colonial period. In particular, additional research should focus on environmental and postcolonial history to understand the influence of colonial-era exploitation on current water availability and accessibility in urban areas.

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Conflicts of interest.

The authors declare no conflict of interest.

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Від панчуран до водопостачання: рішення щодо чистої води в колоніальному Бандунгу, Західній Яві, Голландській Східній Індії (1898–1934)

Анотація. *Це дослідження розглядає управління чистою водою в Бандунгу, Західній Яві, Нідерландській Східній Індії (Індонезія) з кінця 19-го до початку 20-го століття. Це дослідження зосереджено на тому, як людське співтовариство змінило фізичну одиницю води, включаючи технологію, навички управління та соціальні та екологічні пріоритети. Для вивчення теми були використані історичні методи, включаючи евристику, верифікацію, інтерпретацію та історіографію. Більшість даних у цьому дослідженні були зібрані з первинних джерел у вигляді архівів та офіційних документів Департаменту громадських робіт та муніципального уряду міста Бандунг, опублікованих з кінця 19-го століття та до першої половини 20-го століття. Результати показали, що корінні жителі Бандунгу, сунданці, керували джерелами та річками на основі місцевих знань, гармонізуючи просту технологію з природою та віруваннями. Вони використовували панчуран, канал із плетених палиць бамбука, для відведення води з джерел. У той час, як європейці спочатку користувалися копанням криниць для повсякденних потреб у воді наприкінці 19-го століття. Однак у зв'язку зі збільшенням епідемій та швидким зростанням населення на*

початку 20-го століття, з'явилися стурбованість щодо епідемій та потреби в більш обдуманому та професійному управлінні водопостачанням, підкріпленому науковою базою та технологічною інфраструктурою. Уряд муніципалітету Бандунгу залучив інженерів та вчених для дослідження нових джерел води та будівництва інфраструктури для чистої води. До 1930-х років вони змогли побудувати артезіанські свердловини, мережі водопроводів, резервуари, системи фільтрації та громадські об'єкти для чистої води. Уряд муніципалітету Бандунгу розширив діапазон джерел чистої води від міських до гірських районів на північ від Бандунгу. Муніципалітет визнавав, що ресурси чистої води потребують дослідження та раціонального використання. В Бандунгу були доступні два сервіси забезпечення чистою водою: послуги трубопровідного водопостачання, що доставляли воду безпосередньо до будинків, та доступні громадські об'єкти. Корінні жителі Кампонгу використовували громадські об'єкти, тоді як європейці користувалися платними послугами трубопровідного водопостачання.

Ключові слова: *чиста вода; водні захворювання; інфраструктура; техніка; екологічна історія; Бандунг*

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