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Original article

Treatment and technology of domestic sewage for improvement of rural environment in China

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ABSTRACT

It has been recorded that China's rural environment threatened the lives of people due to the large amounts of wastewater treatment. The domestic sewage treatment plants were implemented in many parts of China to improve the environment of the country, and it has been noted that this sewage had a positive effect on the Chinese Rural Environment. Past studies recorded that China reached building sewage treatment plants with the capacity of 125 million m3. Moreover, most of these treatment plants employed Activated Sludge Process (ASP) along with the package treatments such as Anoxix-Oxic processes, Anaerobic processes, Oxidatin Ditch, and Sequencing Batch Reactors. Still there seems to be a gap in the effectiveness of wastewater treatment plants constructed with wastewater rising day-to-day. The main purpose of the current study is to review the rural wastewater treatments such as sewage systems and other treatment plants, which will improve the rural environment in China. This paper also highlights the characteristics of rural domestic sewage treatment. Furthermore, this paper also explores the applicability of rural sewage treatment technology in rural places of China. The challenges of the wastewater treatment in rural areas of China will also be closely monitored by the researcher.

1. Introduction

All of China's sewage treatment depends on a single sewage plant. In order to treat sewage, a great amount of resources and energy must be used manually in sewage treatment plants (Capodaglio and Olsson, 2019). At the same time, many pollutants, such as wastewater and sludge waste, must be discharged. It is therefore expected that several resource, energy, and environmental problems will arise; at the same time these problems could have a significant environmental impact on China, which has been experiencing tremendous economic growth since the 1980 s (Chen et al., 2019). In such a situation, it is imperative that the sewage treatment business assess its environmental sustainability. (Zhang and Ma, 2020) (see Table 1).

Until now, a variety of analysis viewpoints for the sewage treatment business have been explored widely in various sustainable studies (Chai et al., 2021). Many scholars have studied the relationship between the environment in the sewage treatment industry using biological perspective analysis (Newhart et al., 2019), lifecycle assessment perspective, ecology models perspective, energy and economy performances, sewage treatment and water supply efficiency, chemical and physical angles, construction in the wastewater treatment plants, integrating wastewater treatment and incineration plants for energy-efficiency (Li et al., 2018).

China's discharging regulations, such as most nations, are meant to control the discharges at the end of the pipe. Separate discharge limitations for wastewater treatment plants (WWTPs) were first defined by the national standard "Integrated Wastewater Discharge Standard" (Xu et al., 2020). Water pollution from WWTPs has been regulated by national discharge standards set in 2002, which have had a significant impact on the country's environmental standards. It was only after comparing the limitations for industrial wastewater control with the limits for heavy metals and metalloids that the restrictions for heavy metals and metalloids were established (Raper et al., 2018). While these studies focused on typical pollutants like carbon monoxide and ammonia nitrogen, they did not include heavy metals or other harmful

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Table 1
Keywords/Search Patterns.

Geographical Context	Educational Context
China Chinese	China's Rural Domestic Sewage Development of Rural environment of China Treatment of Domestic Rural Sewage Challenges in Rural Domestic Sewage in China Application of Rural Domestic Sewage Treatment Wastewater Treatments in China

pollutants like metalloids. There has also been a lack of an overall view on the discharge of heavy metals and metalloids from WWTPs in China, as well as a systematic way for determining the discharge limitations based on statistical methodologies (Zhou et al., 2018).

Urban areas of China started to recycle water since 1970s. Majority of the cities in China made use of stabilized ponds to treat the wastewater, which were in the form of ponds, channels, and wetlands (Xu et al., 2022). Reusing treated wastewater (reclaimed water) for beneficial purposes such as irrigation, industrial processes, nonpotable urban applications (such as toilet flushing, street washing, and fire protection), recharge of groundwater, recreation, and direct or undirected water supply are all examples of water reuse (Ait-Mouheb et al., 2018). As a result of these improvements, treated water now has the ability to properly remove biodegradable debris, nutrients, and pathogens. Non-potable water reuse dominates the worldwide landscape, yet potable water reuse has been allowed for millennia since downstream consumers essentially manufactured their potable water from rivers and groundwater that had cycled upstream through several cycles of withdrawal, treatment, and discharge.

Rural domestic sewage treatment requires a big investment, but local governments are unable to finance it (Liao 2018). Because of the difficulty of grassroots financial operation and maintenance, environmental infrastructure is being constructed at a low enough rate. Unfortunately, due to widespread financial problems in the village, the majority of the treatment facilities are unable to function properly, so jeopardising the effluent quality requirements and long-term efficiency of the treatment facilities in question (Ding et al., 2021). The maintenance of the infrastructure necessitates a huge investment of money. A sewage treatment plant's annual operating and maintenance costs average about 30,000 yuan, which includes the cost of power, the cost of equipment maintenance and repair, and the wages of the facility's operation and maintenance staff. Due to the unique nature of the sewage treatment process, certain sewage treatment stations need costly treatment consumables to be replaced, and the operation and maintenance costs may be as high as 10,000 yuan. Due to a lack of adequate funding, rural domestic sewage treatment facilities are unable to satisfy the real demands of complete treatment of rural household sewage, which has a significant effect on the environment (Sharma et al., 2020). Hence, China began to utilize recent technologies with the help of international technical exchanges. To encourage the international financial organizations and governments, the Chinese government reframed their wastewater treatment polices in the early 1980s. For this, the Chinese government provided incentives to international equipment providers. By doing so, China built numerous wastewater treatment plants, of which the comprehensive wastewater treatment plant was activated using sludge in 1982 with a capacity of 260,000 m^3 day (Qu et al., 2019). This plant was popularly known as Jizhuangzi plant, Tianjin Province. Later on, several wastewater treatment projects and plants were built in the cities spread across different parts of China like Hubei, Guangxi, Hebei, Zhejiang, Beijing, Shannxi, Jiangsu, Guangdong, Shanghai, and human provinces. By 1995, several cities of China were connected to sewers; and by 2010 the wastewater treatment plants were constructed and connected in the cities to 80% (Guo, et al., 2014, Jing, 2003, Xuejun, et al., 2011). The Fig. 1 indicates the growth of wastewater treatment plants in China in the last two decades. Past studies recorded that China reached building sewage treatment plants with the capacity of 125 million m3. Moreover, most of these treatment plants employed Activated Sludge Process (ASP) along with the package treatments such as Anoxix-Oxic processes, Anaerobic processes, Oxidatin Ditch, and Sequencing Batch Reactors (Xuejun, et al., 2011). Still there seems to be a gap in the effectiveness of wastewater treatment plants constructed with wastewater rising day-to-day. Past studies also stated that not all the treatment plants operate to its maximum capacity (Long et al., 2019). Only 80% of the treatment plants were recorded as under capacity as the cost of operation was too high. At the same time, the sewerage was identified as unfinished (Nie et al., 2010; Song et al. 2014). Even though there are large treatments plants in operation, still large amounts of untreated wastewater are being discharged into rivers resulting in environmental issues.

People in rural areas may be exposed to serious health risks due to the direct dumping of rural home sewage (Li et al., 2019). Diarrhea has been linked to partly and untreated wastewater reuse. Direct contact between agricultural workers and wastewater has been shown to be the primary means of transmission. Worker interaction with wastewater-contaminated soil, particularly that which has been partly treated or untreated, may also put them at risk of pathogen exposure. For those who live near irrigation fields, (Shuval et al. 1986) found that aerosols might cause a diarrheal incidence rate ratio of 1.08. Children and those with impaired immune systems are more susceptible to diarrheal illnesses than healthy adults. Another important health problem linked with the direct disposal of wastewater is the spread of intestinal parasites, particularly soil-transmitted helminths. Dermatitis, urticarial, and fungal infections of the toes and fingernails may all arise from exposure to wastewater (Ngajilo and Jeebhay 2019).

The polluted water can pose potential risks to human beings and hence health becomes the major concern (Wang et al., 2020). To deal with the increasing concern for environmental pollution and human health, Chinese government aimed to build a society that is environment friendly and resource conserving by the year 2015 (Xian-ning, et al., 2006). According to the State Council, resolving the water pollution and other issues relate to environment has been considered as the priority. As a result, the state council encouraged the government to build advanced future wastewater treatment plants across all the cities. In the year 2015, the Chinese Government released a new national strategy to avoid water pollution (Chang et al., 2018). It was also notified

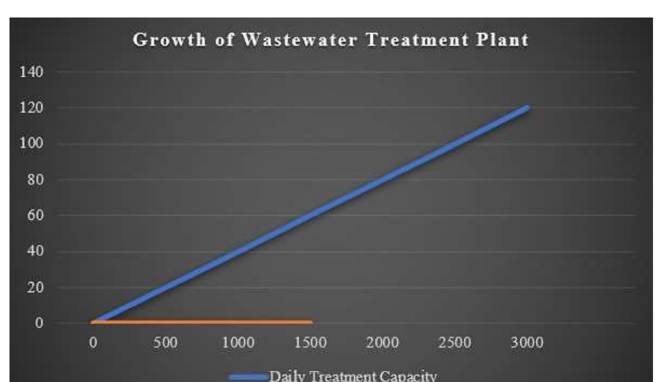

Fig. 1. Growth of Wastewater Treatment Plants in China.

that the quality of water must be improved. All the heavily polluted water must be eliminated by 2020, says the new national strategy (Qu, et al., 2012). Lastly, the whole water ecosystem should be restored by the year 2030 (Qu, et al., 2012, Zhu and Jinren, 2007).

To ensure the safe use of water, especially in the rural areas, Chinese government implemented a project named Rural Domestic Sewage Treatment (Liao et al., 2018). This project was initiated with the intent to improve the rural environment of China. At the same time, it will help the people to have an improved quality of life in rural areas (Zheng et al, 2020). The livelihood of people living in rural areas will be elevated. Even though, China is considered as one of the developed countries, several rural areas in China seem to have an appropriate sewage treatment. Not having a fair sewage treatment and discharge of wastewater can pose a serious threat to the rural environment (Zhang et al., 2021). Recently, several cities promoted the rural domestic sewage water treatment by implementing the concept of lush mountains, lucid waters, and invaluable assets. Due to the rapid increase in the growth of industries in the rural areas, the amount of wastewater discharge has also increased. The discharge of wastewater into rivers or lakes will result in water pollution (Tang et al., 2022). Hence, the water being discharged to rivers must be treated well. For the above reasons, it has become extremely significant to strengthen the construction of future wastewater treatment plants (Longo et al., 2019).

The social structure, economic status, living habits, land areas, and other factors affect the characteristics of wastewater. It was also noticed that China's rural areas development is imperfect due to the inadequacy of funds/resources. Domestic sewages in China were treated up to 13% by the end of 2014. Additionally, rural domestic sewage characteristics are different from cities. Both the technical and management systems of the rural areas are imperfect (Shi et al., 2021). It was also observed that the environmental burden of domestic sewage has exceeded in rural areas than that of Chinese cities (Chen et al., 2021). Henceforth, the Chinese government aimed to formulate and implement advanced sewage treatment plants in rural areas to improve the rural environment, water quality, ad the livelihood of people living in rural areas (Wei et al., 2020). Therefore, the current study aims to review the water pollution in China, the different methods of wastewater treatment in China and its effectiveness in terms of rural improvement, characteristics of rural domestic sewage treatment, challenges of the wastewater treatment in rural areas of China, and the applicability of domestic sewage wastewater treatment. The primary source of rural sewage waste includes farmland storm runoff, diversity of water quality, domestic sewage, livestock sewage, high organic concentration, intermittent discharge, small pollution, and so forth (Xian-ning et al., 2006). There is a high need to control and manage the sewage problem in rural areas and hence this paper discusses the constant practice required to control the sewage problem.

2. Discussion

This section will present the interpretations of the data collected for the research, followed by the review of the data gathered. The Fig. 2 shows the SLR phase.

2.1. Frame research questions and develop protocol

The researchers raised the following research questions to review the effectiveness of rural domestic sewage treatment on the enhancement of rural environment in China: 1) What are the characteristics of Rural Domestic Sewage Discharge? 2) In which research papers, China's Water pollution in rural areas is discussed? 3) What are the wastewater treatments that are currently utilized in Chinese rural areas? 4) What are the challenges China is facing aboutthe wastewater treatment in rural areas? 5) What is the applicability of rural sewage treatment technology in rural places of China?

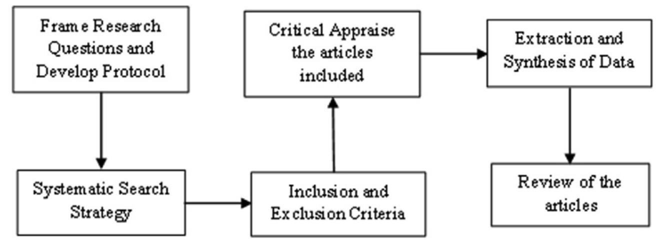

Fig. 2. SLR Phases.

2.2. Systematic search strategy

To address the research question identified, numerous keywords were used in the study. The keywords were broadly divided based on the geographical context and the educational context. Keywords used in the study are presented in Table 3 which includes: China's Rural Domestic Sewage, Development of Rural environment of China, Treatment of Domestic Rural Sewage, Challenges in Rural Domestic Sewage in China, Wastewater Treatments in China, and Application of Rural Domestic Sewage Treatment. The searches for the articles were carried out from multiple electronic databases, which include Wiley Online Library, Science Direct, Springer, China Research Center, and other Digital libraries. The Fig. 3 shows the graphical Representation of the identified themes from research papers.

2.3. Inclusion and exclusion criteria

The research topic selected for this study has several possibilities, for instance, China's Rural Domestic Sewage, Development of Rural environment of China, Treatment of Domestic Rural Sewage, Challenges in Rural Domestic Sewage in China, Wastewater Treatments in China, and Application of Rural Domestic Sewage Treatment. The term 'Wastewater Treatments in China' was searched in the electronic database to ensure that no articles are missed out. Therefore, this study includes the articles and research papers that include 'Wastewater Treatments in China' in the titles, summary, abstract, keywords, and the body of research that were published between the time period of 2010 and 2020. Basically, the inclusion criteria were as follows: 1) research papers; 2) Research Journals; 3) unpublished thesis. Similarly, the exclusion criteria in the study were as follows: 1) research articles written in regional languages other than English; 2) Location of the author other than China; 3) Context of Study other than China; 4) research articles that were not fully available in the electronic database.

2.4. Critical appraise the articles included

Total number of research articles found was 38. Out of them 20 duplicates were eliminated from the research paper. The articles selected for the study were based on their quality, title, keywords, and abstract. Articles, which did not focus on China's domestic sewage treatment, Wastewater treatment in China, Application of Rural Domestic Sewage Treatment, and so on, were eliminated. Later, 7 articles were selected for Systematic Literature Review and the extracted the following data: Title of the paper, name of the author, year of publication, Summary of the paper, and location of context. To analyze and locate the data, a form was used, and the

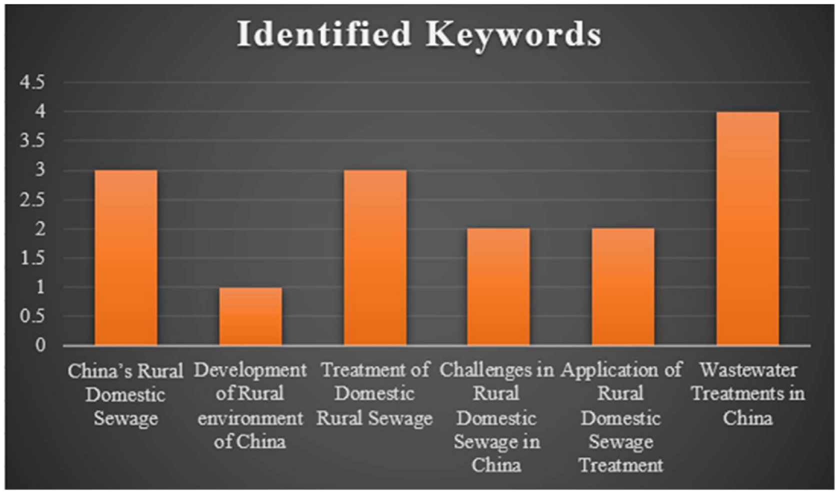

Fig. 3. Graphical Representation of the identified themes from research papers.

answers were validated on a three-peer review. Finally, the reviews shared and discussed approached 100% verification of the data.

2.5. Extraction and synthesis of data

Based on the research questions developed, the data collected were synthesized and further supported the content analysis of the selected research articles. Thus, the study presents the inferences from the content analysis, which is a qualitative technique used to focus on text. Content analysis included two components- mechanical and interpretative. The mechanical component allowed the researcher to organize the data collected into different topics. While interpretative method allowed researcher to explore more on the content according to the research questions. Later, the data synthesized was reviewed by a three-peer group and identified the themes. This peer-review helped this research to get more clarity on the themes or research questions.

2.6. Characteristics of rural domestic sewage discharge

Series of recent studies indicated that the quality of water reaching rural areas of China is high, and people living there use the mountain spring water and groundwater for drinking purposes. Almost 85.4% of rural population accounts the rural tap water for drinking purposes (Wang et al., 2011). As the quality of water reaching rural areas is related to the livelihood and health of the rural people. For the above reasons, it becomes essential for the Chinese government to construct and implement a comprehensive rural domestic sewage treatment to achieve a sustainable development. It was also noted that a comprehensive rural domestic sewage treatment will enhance the rural environment of China by applying the advanced rural domestic sewage technology to treat the wastewater (Ueda et al., 1996; Wei et al., 2012). Literature pertaining to rural domestic sewage treatment and technology strongly suggests that rural domestic sewage discharge is demonstrated in four facets, which are identified as the characteristics of rural domestic sewage discharge. It was reported that rural domestic sewage collection in the Chinese rural areas is extremely substandard. Majority of the rural areas in China are filled with mountains, tourist attractions, catering restaurants, and so forth. Henceforth, the amount of sewage waste is comparatively high in such rural areas. Past studies concluded that rural domestic sewage is not being collected appropriately, leading to major threats (Xi et al., 2014; Zhang, 2009). Additionally, several studies discussed that to construct a domestic sewage treatment plant, government would require high amounts of funds. Since, the Chinese government lacks fund to construct advanced wastewater treatment plants, the sewage discharge gets blocked, resulting in garbage collection. These large amounts of garbage collection are a result of poor domestic sewage treatment (Xi et al., 2014; Zhang, 2009). Few other studies also found that there is a lack of proper coordination in terms of land usage. It is very difficult to procure a land to construct advanced sewage treatment plant. In general, the concerned authorities borrow or rent land to construct rural sewage treatment plants. But people who lack sense of social responsibility fail to cooperate with the authorities to rent or borrow the land. Especially, in rural areas, village people hinder the construction of sewage treatment plants. As a result, the government faces extreme difficulty in successfully implanting a sewage purification project in rural areas (Ding et al., 2021). Lastly, the maintenance of sewage garbage is not maintained effectively, leading to poor water quality, water flow, plant growth, and so forth. In short, sewage garbage, if not well maintained, negatively impacts the rural environment of China. This can be solved by constructing advanced domestic sewage treatment plants (Roy et al., 2017; Zhang et al., 2013; Zhao and He, 2014).

2.7. Water pollution in China's rural areas

Some authors have found further reasons of water pollution in rural areas of China that include changes in the policies of rural wastewater treatment, awareness on rural wastewater treatment, and investment on the sewage treatment plants (Li, 2021). These studies also observed that rural environment pollution is one of the most important social problems affecting the livelihood of people (Asfaw et al., 2010). Majority of the complaints about the water pollution were recorded from Chinese rural areas, when compared to urban areas (Deng and Wheatley, 2016). Results of the past studies showed that China has 2.79 million rural areas of which 768.8 million people represent Chinese population (Liao et al., 2011). In other words, 59% of the Chinese population belongs to rural areas, henceforth; rural areas play a significant role in contributing to the national economy (Chen, 2019). Previous studies have emphasized that water pollution had a grave impact on the whole Chinese agricultural industry, domestic life of people, and even the water supply (Vennemo et al., 2020). One of the studies reported that more than 90 million people are drinking polluted water, especially in rural areas (Shahid et al., 2018). Few other studies stated that 80% people in rural areas are dying as they are drinking polluted water (Wang et al., 2017; Fang et al., 2009).

More than 80% of the world's illnesses originate from water, according to the World Health Organization (WHO) (Islam et al., 2014). Several nations' water supplies do not satisfy WHO guidelines for safe drinking. 3.1 percent of fatalities are attributed to water that is unsanitary and of low quality (Jabeen et al., 2015).

Domestic sewage is said to be responsible for up to 75% to 80% of all water contamination (Haseena et al., 2017). Pollution from sectors such as sugar, textile, electroplating, pesticides, pulp, and paper is contaminating the water supply. Polluted rivers have an unbearable odour and are home to a smaller variety of plants and animals (Kalogerakis et al., 2021). Threats to water security affect 80 percent of the world's population. Domestic sewage is poured into the river in large quantities, and most of it is untreated (Dai et al., 2015). Water pollution is a result of harmful components found in domestic sewage, including toxicants, solid waste, plastic litter, and bacteria. Water contamination is mostly caused by industrial wastewater that is discharged into rivers untreated (Kanu and Achi, 2011). Contamination of surface and groundwater occurs as a result of hazardous material released by industry. Depending on the nature of the industry, contamination may occur (Sharma and Bhattacharya, 2017). Water quality was harmed by the introduction of toxic metals. The industries are responsible for 25% of the pollution, which is more hazardous (Vardhan et al., 2019).

People are becoming infected with a slew of ailments brought on by contaminated water. Extreme weather and flooding are linked to a wide range of illnesses in both developed and poor nations (Ahmed et al., 2016). Food and vegetables cultivated in polluted water are consumed by 10% of the population. The fecal-oral pathway is a common route of infection for many aquatic infectious illnesses (De Graaf et al., 2017). Polluted water puts people at risk for a wide range of illnesses, including respiratory conditions, cancer, diarrhoea, neurological disorders, and cardiovascular ailments (Pruss-Ustun et al. 2016). Tumors and the "blue baby" syndrome are linked to nitrosamines, which may cause cancer. Rural residents die at a greater rate from cancer than city dwellers, in part because city residents have access to purified water, while rural residents do not (Bryan and van Grinsven, 2013). Women who are exposed to toxins while pregnant are more likely to give birth to babies with low weights as a consequence of their foetuses' health being impacted.

Chinese Government provided access to piped water supply to rural population, which led to the accumulation of wastewater (Yu et al. 2015). Rural areas consume more water and produce more wastewater (Deng and Wheatley, 2016). Due to the increased use of washing machines and flush toilets, amounts of rural sewage waste will increase. Table 2 presents the discharge amount and characteristics of Chinese rural wastewater treatment. From the table it can be inferred that water consumption in rural areas is lower than that in the urban areas. In addition to, it can be stated that the characteristics of sewage treatment are different from one place to another, and these are affected by various factors. In terms of agriculture, it was found that China has extensively used inorganic fertilizer and pesticides (Qing et al., 2009). Few other studies also found that China used millions of chemical fertilizers and pesticides. Many of the world's major agricultural regions have experienced a decrease in groundwater quality as a result of the increased usage of agricultural pesticides over the past 20 to 30 years (Burri et al., 2019). As a result of widespread, routine land application of nitrogen fertilisers and pesticides, along with point sources, ground water pollution has become a major issue. Surface water quality is also harmed by groundwater inputs (Xue et al., 2016). Nitrate-nitrogen (NO3-N) concentrations in ground water are increasing worldwide at rates of 0.1 to 1.9 mg/l per year for the past 10 to 20 years, which is consistent with the rise in nitrogen fertiliser. Many shallow groundwater sources now have levels of NO3-N that are higher than what is considered safe for human consumption. In spite of the fact that there are numerous natural sources of nitrogen, synthetic fertilisers have mostly replaced them. A surprising number of pesticides are showing up in ground water, often in amounts of 0.1 to 10 g/1. We are concerned about the possibility of long-term and widespread exposure to potentially toxic or hazardous substances in ground water, even at low levels. Only shallow aquifers are affected at this moment. There may be nothing more to it than that. Chemicals in ground water can spread to deeper aquifers over time if they persist (Lapworth et al., 2018). In most cases, pesticide concentrations are well below acute hazardous (toxic) thresholds. But the long-term chronic health impacts (e.g., cancer, immune system diseases) of pesticides in drinking water remain a matter of debate. There exists a considerable body of literature on water pollution in China and found

Table 2
Wastewater Treatment Discharge amount & Characteristics of Chinese Rural Areas (Deng and Wheatley, 2016). Wastewater treatment in Chinese rural areas. Asian Journal of Water, Environment and Pollution, 13(4), 1–11).

Provinces	Concentration (mg/L)							Water demand (p/I/d)
	pH	**SS**	**COD**	**BOD5**	**NH3+-N**	**TP**	**TN**	
Sichuan	6–9	100–500	62–314	–	3.6–40.5	0.5–12.1	–	70–110
Jiangsu	6.4–8.9	10–507	30–1460	–	1.6–868.9	0.8–70.8	–	55
Hubei	–	43	91	28	24.3	2.33	27.3	50–60
Jiangsu	6–9	250	600	280	–	2.75	38	25–70
Beijing	–	458–2520	135–628	–	–	2.1–7.6	20.2–48.1	95
Yunnan	6.7–8.3	251–969	270–1629	118–342	–	2.1–37.9	24–238	–
Anhui	–	–	800–1200	–	10	4–6	20–40	26
Fujian	–	–	–	–	11.8	2.1	20	54
Chiongqing	–	–	44–456	–	–	9.9–72	0.9–9.8	–
Guangding	–	59–107	182–350	–	0.3–14.3	1.9–2.3	–	71
Zhejiang	6.8–7.4	–	63	18	–	0.023–0.034	0.06–0.13	–
Qinghai	–	–	523.34	–	4.7	4.6	18.7	–
Jiangxi	–	–	17–107		0.3–18.9	0.1–6.0	1.2–40	–
Guangxi	–	72–160	42–296	–	6.8–44.7	2.1–5.2	10.3–51.8	–
Taiwan	6.1–7.1	–	14–383	5–194	0.5–0.9	0.03–4.47	2.1–55.1	–
Shandong	–	337	398	–	–	9.94	125	–
Hunan	–	–	100–500	60–300	15–43	1.8–3.5	29–52	–
Shaanxi	–	–	334–488	92–201	37–50	4.6–5.5	–	–
Guizhou	–	–	77–694	150–350	1–17	1–17	0.5–6.4	5.5–28.6
Ningxia	6.5–8.5	200–300	300–600	35–64	30–80	30–80	5–8	1–10
Hebei	6.8–8.4	–	16–19		2–28	1.4	1.7–28.9	12–28

that village areas were adversely affected due to the water pollution, as the industries discharged the wastewater into rivers, lakes, and other areas. As already discussed, rural areas of China have substandard facilities in terms of managing the discharge of wastewater. Few other studies observed that rural sewage treatment improves the direct discharge of wastewater, eventually affecting the livelihood of people living in rural areas of China (Ju, 2012; Dong et al., 2012).

2.8. Wastewater treatments in China

As has been previously reported in the literature, Chinese government implemented wastewater treatment plants in 79% of the cities, 14% of the towns, and 7% of villages. Chinese rural areas such as Guangdong, Jiangsu, Shandong, Zhejiang, and Shanghai had rural treatment plants that comprised of 7%. From this, it can be understood that many rural parts of China had no treatment plants to deal with the wastewater discharge (Ma and Zhang, 2012). As the rural wastewater infrastructure is not advanced, the rural sewage waste is being dumped into rivers, lakes, or nearby farmlands. Previous studies confirmed that 50% of the sewage discharge is accounted from the rural areas, which constitutes 42% of oxygen demand, 58% of nitrogen gas, and 66% of other chemicals (Dong et al., 2012).Chinese government decided to enhance the sewage treatments in Chinese Urban areas by 31%, which should be supported by financial help. The same plan was advised to the rural areas to enhance the rural environment of China. It was notified that 88% of the sewage treatment plants should be constructed and implemented in the country. This will help the country to manage the water pollution, control sewage waste discharge into farmlands, rivers, and lakes. From the existing literature review it can be inferred that rural areas of China have 1626 sewage treatment plants, predominantly distributed in major provinces like Guangdong, Jiangsu, Shandong, Zhejiang, and Shanghai (Zhu and Jinren, 2007; Li, 2021; Wang et al., 2011). While 628 wastewater treatment plants were constructed in rest of the 27 provinces (Weldeyohannes et al., 2018). Nevertheless, the quality of sewage water treatment is still being questioned by the Chinese government authorities. Table 3 presents the three different types of sewage systems primarily found in rural areas.

This goal was set in 2015, and they have provided financial assistance to help the community realise it. This is the first time therapy has been planned in a rural setting. The revised 2015–2030 plan aims to clean 85 percent of the country's sewage and control agricultural pollution, including pollutant discharge from animal farms, pesticides and chemical fertiliser (The State Council, 2015). Until 2010, China had 1625 rural sewage treatment facilities, 945 of which were concentrated in four main provinces (Jiangsu, Zhejiang, Shandong, and Guangdong) and another 680 in 27 other provinces. 9.54 million m^3/day of rural treatment capacity is now available to the public. To be sure, urban treatment falls short in terms of both quantity and quality.

2.9. Sewer system

In rural China, the sewage system is divided into three distinct tiers. As far as sewage systems are concerned, the biggest and most important towns are linked to one, whereas smaller towns have their own systems. In rural areas, open concrete channels and pipes were used to construct sewage systems. Because of its low weight, lack of corrosion, long-term cheap cost, decreased friction factor, and potential for high service life, UPVC is progressively replacing these materials. In villages, researchers recommended using 200 mm diameter pipes for sub-main and main pipes, and 300 mm diameter pipes for pipelines outside of communities. Inspection chambers should be installed at pipe intersections to prevent blockage, which is the most common cause of carrion complaints. Instead of standard trapezoid flumes, prefabricated U-shaped flumes for chambers may be utilised, and the bottom of the U flume could be adjusted on site using UPVC pipe. In rural regions, cast iron inspection chamber lids were too expensive and vulnerable to pilferage. For the greatest results, steel-fiber reinforced concrete caps were advised.

2.10. Treatment plants

Many studies have shown the existence of different wastewater treatment methods in rural China. The most common kind of sewage disposal system was a septic tank. Because they were so cheap and easy to use, 97% of places have them. In rural areas, a national biogas reactor building plan emphasised the use of anaerobic treatment. Most of the cost was funded by government grants, with the remaining third being borne by the people themselves. Approximately 30% of China's rural population was covered by 40 billion biogas reactors in 2000, according to a research (Aravani et al. 2022). Secondary treatment techniques such oxidation tanks, bio film reactors, built wetlands, and engineered soil treatment were uncommon; fewer than 30% of sites employed any of these. Even in wealthy communities with big populations, standard activated sludge was seldom utilised.

2.11. Physico-chemical parameters of sewage generated and microbial contaminations

The physicochemical parameters of sewage generated were determined by pH, temperature, turbidity, conductivity, total dissolved solids, total suspended solids, total alkalinity, biological oxygen demand, chemical oxygen demand (COD), dissolved oxygen (DO), total organic carbon, sulphate, nitrate (N-NO3), and phosphate (P-PO4).

The pH and DO were determined in situ using a portable multiparameter analyzer. Other chemical parameters such as COD, metals and nutrients were determined according to the standard analytical methods for the examination of water and wastewater. The COD values reflect the organic and inorganic compounds oxidized by dichromate with the following exceptions: some heterocyclic compounds (e.g., pyridine), quaternary nitrogen compounds, and readily volatile hydrocarbons. The concentration of metals was determined as a result of their toxicity.

2.12. Temperature

The pace at which chemical reactions occur increases with rising temperature, and the rate of biological processes normally doubles with every 10 °C rise in temperature. Warm water may dissolve less oxygen physiologically than cold water. This is due

Table 3
Types of Rural Sewage Treatments in Chinese rural areas.

Condition	Within 5km of urban sewer system	Long distance, high costs and geography obstacle to connect with centralized	Individual or few households
Sewer collection system type	Connecting to centralized sewer system	Cluster system	On site system

to the fact that when the temperature rises, the solubility of gases in water decreases. Higher temperature causes increased respiration, which leads to increased oxygen utilization and organic matter breakdown (Pierce et al., 1998). The unusually high temperatures measured would hasten the breakdown of organic stuff in the water, since water temperature impacts the concentration of physical, biological, and chemical elements.

2.13. Total suspended solids (TSS)

The TSS of a wastewater sample is evaluated by putting a precisely measured amount of water through a pre-weighed filter with a predetermined pore size, then drying the filter to eliminate all water. Turbidity is caused by total suspended particles in water or waste water. The higher the TSS, the higher the Turbidity.

2.14. Total dissolved solids (TDS)

Any minerals, salts, metals, cations, or anions dissolved in water are referred to as dissolved solids. Inorganic salts (mostly magnesium, calcium, potassium, bicarbonates, sodium, chlorides, and sulphates) and certain minor quantities of organic materials are dissolved in water to form TDS. According to EPA, permissible amount of TDS in water is 500 mg/L.

2.15. Turbidity

Turbidity is an optical feature of water that causes light to be dispersed and absorbed rather of being transmitted in a straight path. As a result, suspended and colloidal debris such as clay, silt, finely split organic matter, plankton, and other minute creatures generate turbidity in water. The WHO (World Health Organization) recommends that water turbidity should not exceed 5 NTU (Nephelometric turbidity unit) and preferably be less than 1 NTU.

2.16. BOD (Biochemical Oxygen Demand)

BOD is a measure of the oxygen needed to oxidise the desirable organic matter in a water sample to stable inorganic chemicals, and it serves as a rough indicator of organic pollution. Microorganisms that use organic materials as a source of carbon also use dissolved oxygen, resulting in biochemical oxidation.

2.17. Chemical oxygen demand (COD)

The amount of oxygen needed by organic substances in water to be oxidised by a powerful chemical oxidant is known as COD. BOD has an acceptable value of 30 mg/l and COD has a permissible value of 250 mg/l, according to the Central Pollution Control Board's regulations of China.

2.18. Total hardness (TH)

Hardness in water is caused by natural salt buildup in the soil and geological formations, or by direct contamination from industrial effluents. If it's mostly carbonates and bicarbonates, hardness is ephemeral; if it's mostly sulphate and chlorides, it's permanent.

2.19. Acidity

Acidity of water refers to its ability to react with a strong base to a certain pH. The presence of hydrolysable metal ions causes acidity in industrial waste samples, while the presence of free CO_2 causes acidity in fresh water samples.

2.20. Alkalinity

The ability of water to neutralise a strong acid is measured by its total alkalinity. Alkalinity in water is usually provided by salts of carbonates, phosphates, and nitrates, as well as hydroxyl ions in the free form.

2.21. Challenges of wastewater treatment

Past studies discussed the challenges faced by China with regard to wastewater treatment. These challenges include water pollution, environmental pollution, water quality, and so forth. Other difficulties identified include financial difficulty, poor management of sewage treatment plants, lack of appropriate sewage collection system, lack of appropriate treatment facilities, lack of sewage treatment plant standards, lack of poor awareness on sewage treatment and so forth (Deng and Wheatley, 2016; Qing et al., 2009; Dong et al., 2012). Rural sewage treatment plants funding and operational costs should be increased. By sing so, the water supply and other wastewater discharge issues can be treated effectively. Gradually, it will enhance the rural environment and livelihood of the people. Multiple studies pointed out that rural areas of China focused on hindering the construction and maintenance of sewage treatment plants as it effected their livelihood in every way. Poor management, poor operation, and poor maintenance of the domestic sewage treatment plants led to poor environment of rural areas. Few other studies identified problems such as ineffective sewage collection, low-cost maintenance, low performance of the treatment plants, and so on. With respect to poor awareness, it was confirmed that people living in rural areas were not informed about the environment cleanliness and safety. The threats of wastewater treatment were not informed to the people and hence the condition of rural areas was recorded as poor.

2.22. Alternative ways in the maintenance of domestic sewage system

Conventional gravity sewers might be too expensive due to low population density or site characteristics like a high water table or bedrock. Alternatives to conventional sewage systems include small-diameter gravity sewers and pressure or vacuum sewers.

Small-diameter gravity systems (usually 100 mm or 4 in. in diameter) employ septic tanks to remove settleable and floating materials from wastewater before it runs into a collection system. These systems are best suited for small rural populations. They may be smaller in diameter and put at a lower slope or gradient to save trench excavation expenses since they don't transport oil, grit and solid waste. Flat regions or those requiring costly rock extraction are best suited for pressure sewers. Residents' wastewater is collected by grinder pumps and pumped to a central pressure sewer system. By gravity, sewage from a building or buildings runs into a sump or tank from which vacuum pumps placed at a central vacuum station remove it. The sewage then flows into a collecting tank. Pumping the sewage from the vacuum tank to a treatment facility is the process.

2.23. Recycled ceramic membranes, the eco-friendly solution

Alumina, zirconia, and titania oxide, which are used to make classic ceramic membranes, have historically been relatively expensive. The polymeric membrane is now a more preferred substitute owing to its cheaper price. It is true that polymeric membranes are less expensive, but they are not as effective in harsh environments and have a shorter life cycle. Recycling ceramic membranes is REMEB's answer to the issue. Because they don't employ expensive minerals, these membranes are comparable to high-end ceramic equivalents on the market.

From ceramic and marble industries as well as olive oil processing, the membranes are manufactured. Incorporating chamotte (from fired tile debris), marble dust and olive stones into recycled ceramic membranes reduces the cost of production. They also aid in the reduction of landfill trash, encouraging a more circular economic model. Each of the inorganic membranes measures 200 by 500 mm on a flat sheet. Membrane bioreactors (MBRs) have four modules in total. There are 50 membranes in each module that are 10 square metres in area. Additionally, the system is stackable, allowing it to grow in size and capacity. For wastewater treatment, the MBR utilises membrane technology and a biological process. As a result of the use of membranes, the biomass and the treated water are separated. The membranes' small holes trap suspended particles and other things, enabling only clean water to travel through the membranes and through the pipes.

2.24. Other shortcomings of present methods of wastewater treatment system

It requires a significant investment in terms of money, power, and personnel. Even if you meet all of these criteria, wastewater treatment may still be a challenge. As a result, an environmentally friendly approach to wastewater treatment may be the best choice. It has the advantage of being low-cost and simple enough to be operated by anybody with very little training. In addition, the cheaper costs of the natural wastewater treatment facilities make it accessible to everyone.

2.25. Rural sewage treatment technology

Many existing studies in the broader literature have discussed that rural domestic sewage waste is predominantly formed from kitchen waste, bathroom waste, washing waste and others. Various other factors of pollution include emission of pollutants, issues of eutrophication, and so on. Currently, three major rural domestic sewage treatment plants were identified, which will enhance the rural environment of China. It was demonstrated that advanced implementation of domestic sewage treatment plants will improve the rural environment of China by reducing the wastewater discharge directly into the lakes, rivers, and farmlands. For this, advanced sewage treatment plants should be constructed with less operational cost, low energy consumption, and choose the appropriate sewage collection and treatment methods. Fig. 4 presents the sewage treatment process followed in major places of China.

To guide the market for sewage treatment in China, the Chinese government issued policies designed to regulate the industry strictly. However, China's urbanization and urban population continues to grow. As a result, municipal sewage discharge keeps increasing. During 2016, the daily amount of sewage discharged by municipalities amounted to 150 million cubic meters. The urban population in China is projected to grow with the domestic sewage discharge. Through the expansion of the sewage network by 125,900 km, the government of China has strategic plans to increase the efficiency of sewage collection and raise the capacity utilization ratio of sewage treatment plants (Mumbengegwi et al., 2018). The treatment rate of urban areas is analysed based on the scale, treatment process, geographical distribution, and discharge standards. The amount of medium scale wastewater treatment plants in China accounted for 75% of the total amount of 3836. On average, medium scale plants achieved a COD removal efficiency of 85.5%. Around 30% of China's water treatment plants use oxidation ditches, 16.2% use anaerobic/anoxic/oxic processes, 10% use activated sludge, 8.2% use anaerobic processes, and 6.8% use sequencing batch reactors. Thickening, dehydrating, and eventually disposing of sludge in landfills was part of the sludge treatment process. An online monitoring system is in place at all wastewater treatment plants for data collection and compliance assurance. The different levels of treatment facilities were built as a result of the different levels of GDP throughout the country. Treatment plants at large scales are highly automated, so there is less need for staff. As a result, the cost of operating the plant was higher. Large-scale plants may not have been affordable in smaller cities because of this cost. Consequently, small and medium-sized plants were far more popular due to the reduction of electricity and labour costs as well as the use of chemicals (Mumbengegwi et al., 2018).

3. Conclusion

The paper concludes by arguing that the constructing domestic sewage wastewater treatment plants will enhance the rural environment of China. There has been a gradual growth in the treatment plants. It was notified that 88% of the sewage treatment plants should be constructed and implemented in the country. This will help the country to manage the water pollution, control sewage waste discharge into farmlands, rivers, and lakes. Hence it can be concluded that Treatment and Technology of Domestic Sewage improves the Rural Environment in China. In the following methods, sewage treatment may be more efficient:

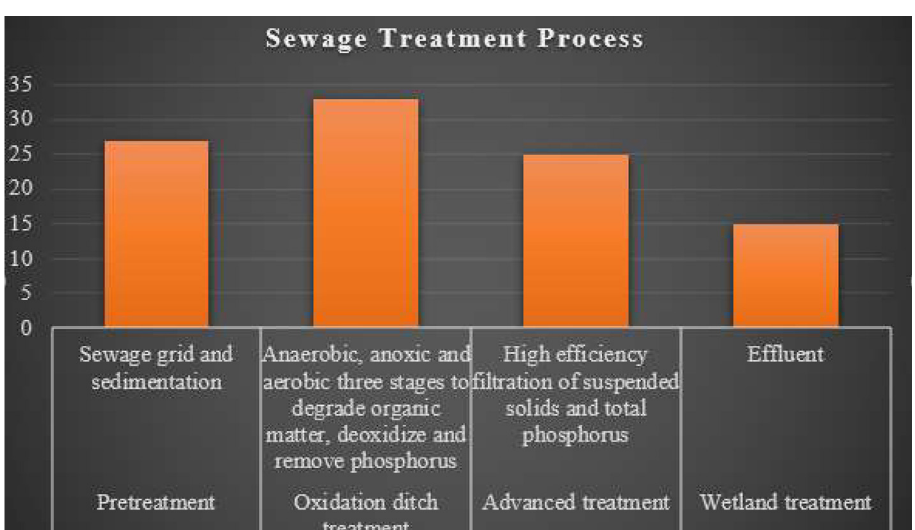

Fig. 4. Sewage Treatment Process.

Drains that get clogged with non-biodegradable debris, such as plastic, should not be used, preventing biological and e-waste materials like metals and chips from clogging the drain, hand sanitizers, non-foam soaps, and other toiletry items that might clog the drainage system should be used.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contribution

This study was done by the authors named in this article, and the authors accept all liabilities resulting from claims which relate to this article and its contents.

Availability of data and materials

The data used to support the findings of this study are available from the corresponding author upon request.

Statements and declarations

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