Wastewater Treatment and Recycling of Western Sydney Airport

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DOI: 10.32629/aes.v3i4.1071

Abstract: The topic of this thesis is wastewater treatment and recycling of Western Sydney Airport. Due to the airports' increasing demand for water and the limitation of total water resources, it is necessary to design a wastewater treatment and recycling system for Western Sydney Airport. There are two primary types of wastewater generated by an airport: wastewater generated by passengers and wastewater generated by the operation and maintenance of the airport. The treatment of these two types of wastewater should be designed separately since these two types of wastewater have different pollutants. The primary pollutants of wastewater generated by passengers are similar to domestic wastewater, which contains organic pollutants, the primary pollutants of wastewater generated by the operation and maintenance of the airport are nitrogen and carbon compounds. By designing a wastewater treatment and recycling system, the water consumption of the airport can be reduced significantly.
***Keywords*:** airports, wastewater treatment, wastewater recycling, Western Sydney Airport, water reuse

1. Introduction

1.1 Background information

The Joint Study on aviation capacity in 2012 indicated that Kingsford Smith Airport (Sydney Airport) could not meet the increasing aviation capacity demand in the Sydney region (Department of Urban Infrastructure, 2016). There is an emergency need to build a new airport to provide more aviation capacity. Western Sydney Airport's development is a multi- government project initiative, and the construction plan is that Western Sydney Airport will be developed over 15 years in several stages. It is a significant transport hub influencing Sydney's future growth and development, and it will have a significant impact on Sydney's commerce. The location of Western Sydney Airport is about 50 kilometres from the central business district of Sydney, and it is surrounded by Elizabeth Drive, Willowdene Avenue, The Northern Road and Badgerys Creek (Department of Urban Infrastructure, 2016). Figure 1 shows the exact location of Western Sydney Airport. The current area of the Airport is approximately 1,780 hectares (Department of Urban Infrastructure, 2016).

Figure 1. Location of Western Sydney Airport (Department of Urban Infrastructure, 2016)

The construction of Western Sydney Airport is underway and plan to begin operation in 2026. Western Sydney would be Australia's third-largest economy and fourth-large city, but it does not have an airport (Department of Urban Infrastructure, 2016). People living in Western Sydney have the potential need for their airport. The benefits of building Western Sydney Airport are listed below (Department of Urban Infrastructure, 2016):

- Around three million people will live in Western Sydney, and Western Sydney Airport can provide aviation services for these residents.
- The demand for passenger journeys will increase from 40 million to 87 million in the next 20 years.
- The airport can generate about $24 billion in direct expenditure by 2060, and $23.9 billion in Gross Domestic Product will be contributed.
- The airport can create the job, offer employment opportunities.

The operation and maintenance of an airport can consume a large amount of water, and these wastewaters may contain a high concentration of pollutants (Baxter et al.,2018). Therefore, it is necessary to consider the wastewater treatment and recycling of the airport. The position of our team is the members of an organization that is a 'Consulting Engineer' working directly for the Western Sydney Airport Corporation. The main topic of this Thesis is wastewater treatment and recycling of Western Sydney Airport.

1.2 Thesis outline

The first part of this thesis is a literature review that pays attention to the basic information of Western Sydney Airport, which includes the need for a new airport, activity forecasts. Then it will talk about the recycled water requirement of Western Sydney Airport. Then, different types of wastewaters generated by an airport will be introduced with their specific treatment approach. The necessity of building a wastewater treatment and recycling system will be mentioned. Then the wastewater recycling system will be introduced.

The second part is the method part, which contains all the calculations for the wastewater treatment and recycling system design. Then the design process for wastewater treatment and wastewater recycling will be explained separately with any notice.

The third part is the outcomes and discussion part, which will detail the critical findings of the research and the applications. Some limitations and improvements will be mentioned as well.

The final part is the conclusion part which will give a concise summary of this thesis.

2. Literature review

2.1 Basic information of Western Sydney Airport

2.1.1 Need for a new airport

The Joint Study in 2012 found that (Department of Urban Infrastructure, 2016):

- All slots between 6 am and 12 noon and between 4 pm and 7 pm on weekdays would be fully allocated by 2020
- All slots will be allocated, and over 100 flights per day cannot be allocated by 2027
- No usable capacity available for new services at Sydney Airport by 2035

It is expected that the number of average passengers of Sydney Airport can reach 74.3 million per year (Department of Urban Infrastructure, 2016). If no additional aviation capacity in the Sydney basin, the domestic airlines will be constrained, and new airlines cannot be accommodated. The Joint Study estimates that about 54 million journeys will be unmet, and the associated economic cost is about 34 billion dollars and 77,900 jobs by 2060 (Department of Urban Infrastructure, 2016).

The construction of this Airport is asked to achieve the following goals (Department of Urban Infrastructure, 2016):

- Provide aviation services for Western Sydney
- Improve the long-term aviation capacity in Sydney
- Maximise the economic benefits
- Provide job opportunities

2.1.2 Activity forecasts of Western Sydney Airport

Table 1. Summary of activity forecasts

	Stage 1	First runway at capacity (2050)	Long term (2060)
Annual passengers	10 MAP	37 MAP	82 MAP
Busy hour passengers	3300	9500	18700
Total annual ATM	63000	18500	370000
Total busy hour ATM	21	49	85

In table 1, ATM means air traffic movements. MAP means millions annual passengers. Table 1 summarises the indicative forecasts for the key stages of Western Sydney Airport. The 2015 passenger number for the top five Australian airports were (Department of Urban Infrastructure, 2016):

- Sydney Airport 39.8 MAP
- Melbourne Airport 32.8 MAP
- Brisbane Airport 22 MAP
- Perth Airport 12.6 MAP
- Adelaide 7.7 MAP

2.1.3 Recycled water requirements of Western Sydney Airport

It is expected that the amount of treated wastewater can exceed the demand for recycled wastewater (Department of Urban Infrastructure, 2016). The treated wastewater will be discharged through irrigation within the airport site.

Airports need to consume a large amount of water for operation and maintenance, and efforts should be made to reduce water consumption by using water efficiently and recycling water (de Castro Carvalho et al., 2013). Most of the water using by airports is the non-potable purpose. The standard for non-potable water is lower than potable water. Thus, it is a good idea to use recycled water for non-potable use.

The wastewater generated by airports have some similar pollution with industrial wastewater (Baxter et al., 2018):

- Potential contamination of drinking water supplies
- Aquatic life in the water may receive potential toxic compounds
- Dissolved oxygen levels may decrease in the receiving water, and fish may die
- Persons who are exposed to the contaminated water have the potential for acute exposure to irrigation

2.2 Type of wastewater generated by airports

2.2.1 The type of wastewater generated by people at the airports

The water consumed by airports can be roughly divided into two parts, the water consumed by the operation and maintenance of airports and the water consumed by people in airports like passengers and airport staff (Baxter et al., 2018). The types of wastewaters generated by these two parts are different. The type of wastewater generated by people in airports is similar to domestic wastewater. These wastewaters can include flushing water used in toilets, washing hands, cooking water used in airport restaurants and other wastewater generated by people. The treatment of these wastewaters can consult domestic wastewater treatment. The literature review about wastewater type can help identify the type of wastewater generated at airports and find suitable approaches to purify different wastewater.

2.2.2 The type of wastewater generated by the operation and maintenance of airports

A large amount of wastewater is generated with a high concentration of pollutants (Baxter et al., 2018).

Airports need to consume a large amount of water to keep their infrastructure working. For de- icing the aircraft, many chemicals are a basic need (Rodziewicz et al., 2019). One primary source of water and land pollution is chemicals used in winter for airports maintenance (Rodziewicz et al., 2019). These chemicals are used at airports to de-ice aeroplanes and airport pavements to ensure a safe air journey. The majority of these chemicals dissolved in rainwater to the ground and the immediate water area (Rodziewicz et al., 2019). These chemicals can include urea, solid form acetate and sodium format and liquid form acetate and potassium format (Mielcarek et al. 2019). The generated wastewater has high nitrogen and carbon compounds (Mielcarek et al., 2019). The composition of wastewater used for de-icing is characterized by chemical oxygen demand (COD) from several dozen to 630,000 mg O2 / dm^3, the concentration of total nitrogen (Kjeldahl) from 0 to 600 mg/dm^3, the concentration of total phosphorous below 1 mg/dm^3 (Rodziewicz et al., 2019).

Most airports are not designed with a wastewater treatment system (Rodziewicz et al., 2020). The design of Western Sydney Airport should consider designing a wastewater treatment system to be a modern airport.

The wastewater coming from the airplane toilet is produced during travel and pre-treated by adding a cleaner, and these wastewaters are typically treated with other wastewater generated by airports (Xu et al., 2011). However, due to the high concentration of ammonia, biological treatment is not a good approach (Da et al., 2017). These wastewaters should be treated separately.

These articles indicate that wastewater generated by the operation and maintenance of airports has a high concentration of nitrogen and carbon compounds, ammonia and other chemicals. Biological treatment is an effective approach to do the purification.

2.3 The necessary of building a wastewater treatment and recycling system at an airport

The significant increase of aviation result in a huge increase of airports' water usage. The water used by airports is estimated to be identical to the water used by mid-size cities (Baxter et al., 2018). Thus, it is essential for airports to reduce the amount of using water. What is more. The wastewater generated by airports can have a high concentration of organic pollutants which may do harm to the residents live nearby if the wastewater is not pre-treated by the airport. The Western Sydney Airport needs to be designed with wastewater treatment and recycling system to reduce the discharge of wastewater and the consumption of clear water.

Osaka's Kansai international airport is the third busiest airport in Japan; the design of this airport considered sustainable environmental management and sustainable water management (Baxter et al. 2018). The method used by Osaka's Kansai airport to reduce water usage is to recycle water as much as possible. The water ratio of this airport is 66.1% in 2015 (Baxter et al. 2018). The design of wastewater management of Osaka's Kansai international airport can be an excellent example of the design of Western Sydney Airport.

The articles about water recycling support the thesis's argument that airports should be equipped with water recycling system to reduce water consumption.

2.4 Wastewater treatment design

Biofilters can treat the wastewater generated by the operation and maintenance of airports. The majority of pollutants in wastewater are nitrogen compounds, and biofilters are suitable to remove them. The result from previous research shows biofilters filled with lightweight aggregates prepared from fly ash can be effective for removing nitrogen and organic compounds (Rodziewicz et al.,2020). Rodziewicz (2019) research showed that biofilters are effective in an extensive temperature range when removing nitrogen compounds. It is suitable for Western Sydney Airport, the wastewater treatment system will be effective since the temperature of Sydney will be a suitable temperature for biofilters.

It is a rough design, and more research will be done to complete the design. However, building biofilters is a suitable approach for wastewater treatment. The biofilters design will be explained in detail in the thesis, and more literature review will be done for this section. It is the right direction to find more articles about biofilters.

For the wastewater generated by people, the activated sludge process (ASP) is the most common method to purify these wastewaters (M. Najy et al. 2020). This treatment process can remove most organic pollutants (Hartley, 2008). Nutrients in these wastewaters will also be removed (He et al. 2018). These two pollutants are the majority pollutants in domestic wastewater (M Najy et al. 2020), similar to the wastewater generated by people in airports.

By doing a literature review about wastewater treatment, the wastewater treatment system design in Western Sydney Airport be more apparent. The draft treatment system will contain biofilters to treat wastewater generated by operations and maintenance of the airport and ASP to treat wastewater generated by people.

2.5 Wastewater recycling design

Airports can reduce water consumption since airports consume much water, and many airports worldwide are finding ways to reduce water consumption (de Castro Carvalho et al., 2013).

The ideal approach to reduce water usage is to recycle it. Osaka's Kansai International Airport is an excellent example of Western Sydney Airport's wastewater recycling design. The measurements taken by this airport include (Baxter et al. 2018):

- Reusing wastewater generated by toilets for irrigation
- Reduce water consumption of the airport

- Collect rainwater for flushing toilet
- Protecting groundwater near the airport away from pollution
- Monitoring airport's water consumption
- Monitoring water quality of the groundwater to ensure they are not polluted.

The cost of purifying wastewater is very high and about 100 times the cost of primary treatment (Bieliatynskyi et al., 2018). Since most water consumption in an airport is not portable, the primary treated water can be used for other purposes.

When design a recycling water system, the rational use of water should be considered, the first step is to do a systematic evaluation of the activities and sectors in which water is used (de Castro Carvalho et al., 2013). Water-saving sanitary fixtures should be considered as well. An example is Atlanta Airport replaced 630 toilets that used 6.05L per flush with water-saving toilets that used 4.84L per flush, and 1200 urinals that used 3.8 L flush were replaced by water- saving urinals that used 1.9 L per flush (de Castro Carvalho et al., 2013).

These articles about water recycling improve the water recycling system design of Western Sydney Airport. The design can be based on other airports' wastewater recycling systems like Osaka's International Airport.

3. Method

3.1 Estimation of wastewater generated by people at Western Sydney Airport

The estimated annual passengers by 2060 are about 82 million, and the total annual air traffic movements are estimated as 370,000 (Department of Urban Infrastructure, 2016). The data from de Castro Carvalho et al. (2013) shows the average water consumed by passengers at Sydney Airport is 30 L. it is estimated that passengers at Western Sydney Airport consumed the same water as Sydney Airport

Then the total annual water consumed by people at Western Sydney Airport is estimated as 82,000,000*30, which is 2,460,000,000 L per year. Then the annual water consumed by passengers should be divided by 365 to calculate daily water consumption, which is about 6,740,000 L/day.

The number of busy hour passengers should also be considered, which can determine the maximum capacity of the wastewater treatment system. The number of busy hour passengers is 18,700 in the long term, then the busy hour water consumed should be estimated as 18,700*30, which is 561,000 L. The busy hour of one day is estimated as 10 hours. The total wastewater generated by people on a busy day should be calculated as 67400/24*14 + 561000*10, which is 9,541,667 L/day. The design should consider the estimated error. The capacity of the activated sludge process should be designed as 10,000,000 L.

Table 2. Summary of estimated water consumed by passengers

Estimated annual passengers	Water consumed by one passenger (L)	Annual water Consumed by passengers (L)	Water consumed by passengers per day (L)
82,000,000	30	2,460,000,000	6,740,000

Table 3. Summary of estimated water consumed by passengers in busy day

Water consumed by one passenger (L)	Busy hour water consumption (L)	Busy hour of one day	Total wastewater generated by passenger in busy day (L)
30	561,000	10	9,541,667

3.2 Estimation of wastewater generated by the operation and maintenance of Western Sydney Airport

The results from Baxter et al. (2019) and Baxter (2021) indicated that the water consumed by passengers contribute for about 20 % of the total water consumption of an airport. Thus, the wastewater generated by the operation and maintenance of Western Sydney airport is 4*6,740,000 which is 26,960,000 L/day.

In busy days, the wastewater generated should be estimated as 10,000,000*4 which is 40,000,000 L/day.

Table 4. Summary of estimated wastewater generated by the operation and maintenance of Western Sydney Airport

Normal day (L)	Busy day (L)
26,960,000	40,000,000

3.3 Design of Activated Sludge Process (ASP)

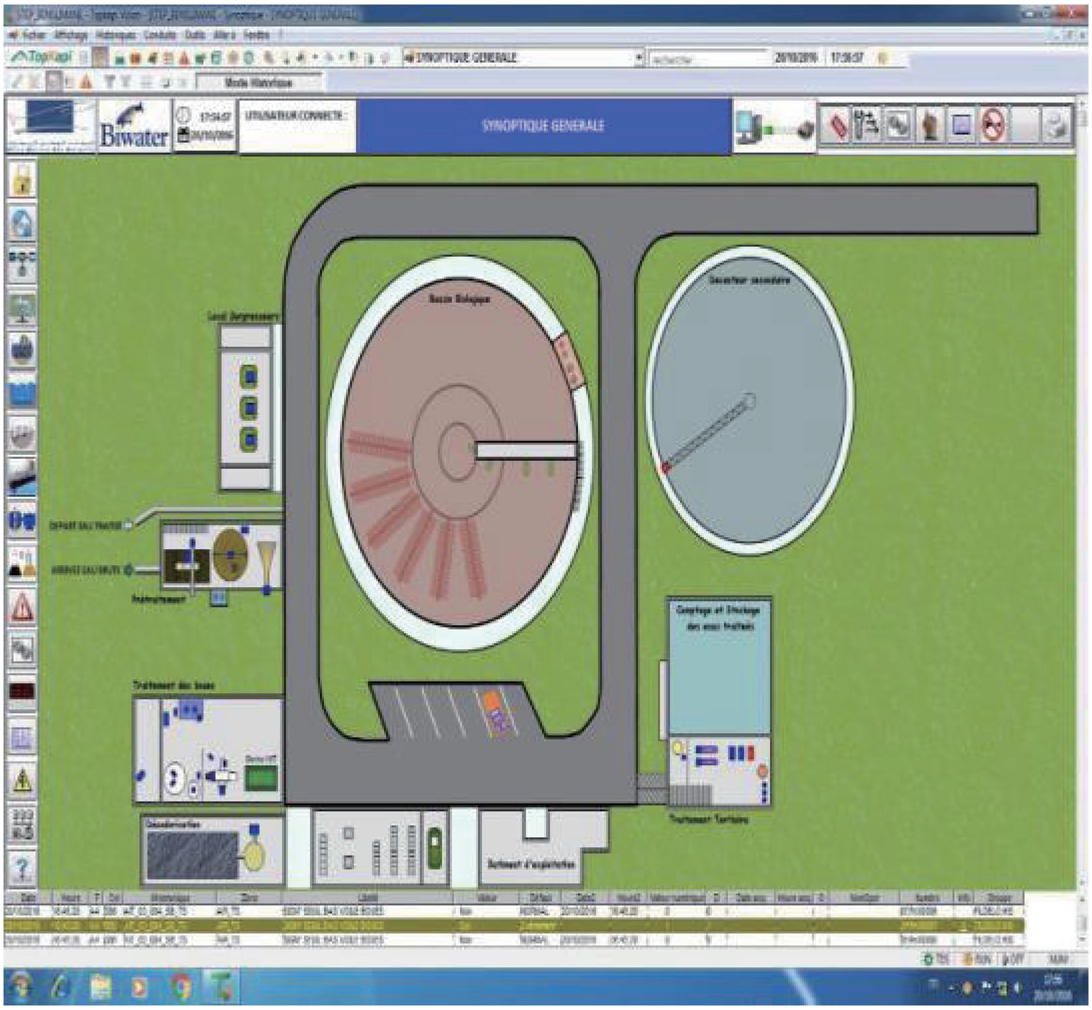

Figure 2. An example for activated sludge process (M. Najy et al., 2020)

Figure 2 is an example of the activated sludge process; wastewater should be pretreated to break down the organic pollutants, then these wastewaters will be sent to the natural basin. The principle of this process is to let the organic pollutants into contact with the microbial culture.

The following steps are the details of the ASP (M. Najy et al., 2020):

- The first step is to wait for the contaminants to be consumed by microorganisms, and the contaminants are transformed into cellular constituents.
- Add coagulant, and the recommendation is aluminium sulphate
- The microorganisms and other suspended matter will be separated from the treated water at the secondary settling tank.

The purpose of the recirculation of sludge is to keep bacterial mass keep a constant level. The location of the activated sludge process equipment should be built outside the Airport. The maximum wastewater treating ability of the system is designed to be 10 million L per day.

A series of work need to be done by the operator of the activated sludge process:

- Conduct three-level safety education in sewage treatment plants, factory-level safety education, workplace-level safety education and post safety education. Concept of finite space and matters needing attention
- Familiar with and master the central control room monitoring system and performance characteristics, test points and test items of all kinds of instruments in the site
- Do the measurement work (like COD, PH, sludge settlement ratio) accurately and on time.

- Complete production operation and generate monitor table on time
- Closely monitor the running status of equipment.
- According to the actual adjustment of the running status of the equipment
- Do the daily maintenance of equipment.
- On-site supervision
- Ensure the integrity of equipment

3.4 Design of Biofilters

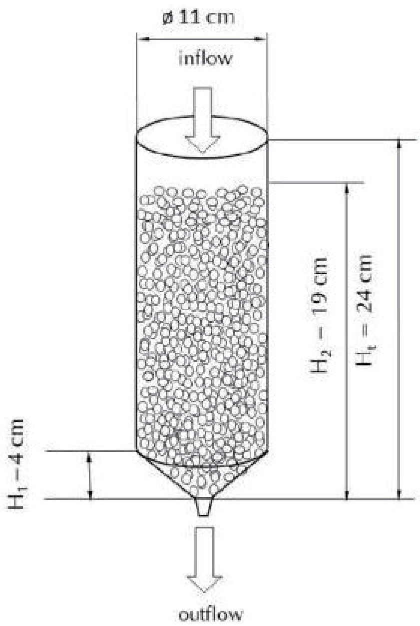

Figure 3. Biofilter with LECA (Light Expanded Clay Aggregates) filling (Rodziewicz et al., 2019)

Figure 3 is an example of biofilter treatment, the biofilter is filling with LECA, and wastewater flows through the biofilter. The biofilter can remove most of the pollutants. The filling of the equipment is granulated, and the LECA is prepared from fly ash using sewage sludge (Rodziewicz et al., 2019).

According to the experiment result from Rodziewicz et al., the most suitable reaction temperature for the organic compounds is 25. Thus, the temperature of these biofilters should be designed as 25 to ensure the efficiency of organic compounds removal. The maximum treating ability of biofilters is designed to be 40 million L per day.

A series of work need to be done by the operator of the biofilters:

- Check whether the coarse grille transmission chain and grille bar fall off or break.
- Check whether the liquid level difference is average.
- Check whether the grid, film grid fouling and failure.
- Ensure the automatic control panel of the electric control cabinet has a no-fault alarm
- Check whether there is any abnormality in each electric control cabinet, abnormal noise and abnormal vibration in the water pump.
- Check whether there the medicine barrel is sufficient, whether there is a leakage of medicine.

All the following items need to be checked during the operation:

- Anaerobic fixed film reaction
- Distribution well
- Primary settling tank

- Sludge thickener
- Blower room
- CAST pool
- Secondary sedimentation tank
- Denitrification filter
- Raising standard pool

3.5 Water recycling

3.5.1 Rainwater reuse

The rainwater harvesting technology is becoming more valuable since the qualitative and quantitative scarcity of water resources (de Castro Carvalho et al., 2013). Since the impermeabilization of the soil, airports contain a tremendous amount of drained water, which shows that airports can reuse rainwater.

Rainwater can be stored during rainy days and can be used after essential treatment. Buildings at the Western Sydney Airport can be fixed with rainwater collectors, and the rainwater collected can be used for flushing toilets and cleaning purposes.

3.5.2 Grey water reuse

Greywater can consist of the water used by washing machines and kitchens. These waters contain a low concentration of pollutants and are suitable for some purposes like flushing toilets.

The greywater recycling system of Hongkong Airport can be seen as an example of greywater reusing at Western Sydney Airport. The treatment system of Hongkong Airport can collect greywater from terminal building kitchens and aircraft washing activities, and the treated water is reused for irrigation (de Castro Carvalho et al., 2013). The reuse of greywater can meet all of the airport's landscape irrigation (de Castro Carvalho et al., 2013).

3.5.3 Seawater reuse

Seawater can also be seen as an alternative water resource to non-potable water. It is attractive to airports that are located near the coast. Seawater can be used for toilet's flushing and cleaning after treatment.

The Hongkong Airport use seawater to supply 41% of the water demand. A small part is used for aeroplane lavatory waste and airport toilets' flushing, and a large part is used in the cooling system (de Castro Carvalho et al., 2013).

3.5.4 Wastewater reuse

Wastewater reuse is a potential choice for Western Sydney Airport. The treatment cost of wastewater is greater than rainwater, greywater and seawater. If the reuse of these three types of water cannot meet the demand of Western Sydney Airport, the reuse of wastewater can be taken into consideration.

The treated wastewater can be used for irrigation, cleaning, toilets' flushing. Sydney Airport can save an average of 580,000 L per day in 2011, and it is expected that this number can reach 1,000,000 L per day (de Castro Carvalho et al., 2013).

4. Outcomes and Discussion

4.1 Key findings and the application of the research

In the thesis, the potential wastewater generated by passengers and Western Sydney Airport is estimated. The amount of wastewater generated by passengers is calculated as 2,460,000,000 L per year and 6,740,000 L per day. There are some busy hours for an airport, for example, the number of passengers will increase in holidays.

The sharp increase in passengers may cause a sharp increase in water consumed. This will result in a sharp increase in wastewater generated by passengers, the peak flow of the wastewater may exceed the maximum capacity of the treatment system if it is not considered in the design process. Thus, the busy hour wastewater generated should be calculated as well.

The estimated number of busy hour passengers is 18,700 and can generate 561,000 L wastewater per hour and 9,541,667 L wastewater per day. Thus, the maximum capacity of the treatment facilities is designed to be 10 million L.

The potential wastewater generated by the operation and maintenance of Western Sydney Airport is estimated as well. Since the exact data for this part of wastewater cannot be found, the calculation of this part of wastewater is based on the proportion of wastewater generated by passengers. The wastewater generated by passengers usually contributed 20 % of the total wastewater. The amount of wastewater generated by the operation and maintenance of Western Sydney Airport is calculated by four times the amount of wastewater generated by passengers.

The total wastewater generated by the operation and maintenance of Western Sydney Airport is calculated as 26,960,000 L on regular days and 40,000,000 L on busy days. Thus, the maximum capacity of the treatment facilities is designed to be 40,000,000 L.

For the water recycling part, the finding is that rainwater and seawater can be reused as well. Since Sydney is a coastal city, seawater resources can be seen as an alternative water resource with no rainwater.

The greywater produced at the airport is an ideal water resource for recycling. Though the greywater cannot drink, it can be used for toilet flushing and irrigation after simple treatment. Greywater is much cleaner than other wastewater types. The cost of recycling wastewater can be reduced by recycling greywater.

By doing the research, it is found that many new airports worldwide pay attention to wastewater treatment and recycling. The measurements taken by these airports can be good examples for the design of Western Sydney Airport. For example, seawater supplies more than 40% of the water demanded by Hongkong Airport.

Some measurements like using water-saving sanitary fixtures can be considered in the design process of wastewater treatment and recycling systems. The data from Hongkong Airport showed that the water consumption of passengers could be reduced to 2/3 by using water-saving toilets.

From the Western Sydney Airport Plan (Department of Urban Infrastructure, 2016), it can be found that Western Sydney Airport tries to recycle wastewater as a critical part of its sustainable water management. New airports worldwide have almost all pay attention to sustainable water management; they are trying to find approaches to reduce water consumption and recycle wastewater. The plan of the Western Sydney Airport also encourages the recycling of wastewater and reuse of treated wastewater. Recycled water can be used for toilet flushing, irrigation, and washing roadways.

4.2 Estimation error

Since the data used to calculate the wastewater generated is all estimated data. Furthermore, it is a long-term estimation, the number of passengers may increase or decrease by 2060. The average water consumption data of passengers is based on the data from Sydney Airport, and water consumption may decrease when using water-saving facilities.

What is more, the number of passengers may be affected by many factors. The design of the wastewater treatment and recycling system should have surplus capacity.

4.3 Wastewater treatment requirements

Some requirements asked by the Western Sydney Airport Plan (Department of Urban Infrastructure, 2016) need to be met:

- At least two days' redundancy stored on-site need to be provided by water infrastructure
- The production of treated wastewater should exceed the demand for recycled water

4.4 Discussion

A limitation is that the exact data of water consumption cannot be found. Since the construction of Western Sydney Airport is still underway, all the data are estimated. For example, the water consumption data for passengers are estimated to be identical with the water consumption per passenger at Sydney Airport. If Western Sydney Airport uses water-saving facilities, the estimated data may significantly differ from the accurate data.

What is more, some water consumption, like fire control systems, did not be calculated in the Thesis. The actual water demand of Western Sydney Airport may exceed the estimation. For the operation of wastewater treatment and recycling system, some requirements need to be met by the operator:

- Annual and monthly production plans should be prepared and implemented
- The original records in the wastewater treatment process should reflect integrity, accuracy and traceability.
- The relevant files and materials should be safely kept for further checking.

The treatment process may be developed in the future, and it should be considered when design the wastewater treatment and recycling process. During the construction of Western Sydney Airport, there are several stages. The facilities that were constructed later can be improved depending on the new technology.

4.4.1 Biofilters

The results from others' reports show that the wastewater treatment process may be affected by factors like temperature.

It is found that 25 °C is an ideal temperature for wastewater treatment, especially for biofilters.

The results of Rodziewicz et al. (2019) and Mielcarek et al. (2019) showed that when the temperature is 25 °C, biofilters have the most efficient carbon and nitrogen compounds removal ability. If the C/N ratio of the carbon and nitrogen compounds is not ideal, the removal ability of biofilters may be reduced at a low temperature. Since the C/N ratio in the wastewater cannot be controlled, the reaction temperature of biofilters should be kept at 25 °C. 90% of the total pollutants in the wastewater can be removed by biofilters at the temperature of 25 °C.

4.4.2 Activated sludge process

The primary problem caused by the wastewater generated by passengers is Eutrophication (M Najy et al., 2020). The wastewater from airports is enriched with P, which is used by plants to grow. The growth of plants will result in algae, which may damage the wastewater treatment facilities; these plants should be cleaned at a fixed period to prevent the potential damage.

The results of M Najy et al. (2020) showed that the activated sludge process could remove 80 % of the pollutants.

4.4.3 Recommendations

According to the Airport plan (Department of Urban Infrastructure, 2016), the airport's construction is divided into three stages. The construction of the wastewater treatment and recycling system can be constructed separately as well. The first stage's construction of this system should consider the connection to the wastewater treatment system that be built in the future. Some treatment facilities like the dominant reactor pool should be constructed. First, the less critical facilities like storage tanks can be constructed later when the maximum capacity cannot meet the demand.

5. Conclusion

In this thesis, the basic information of Western Sydney Airport is provided in the background information and literature review part. To meet the increasing demand for aviation services, it is necessary to build a new airport. When designing the airport, how to reduce water consumption by the airport is the key topic of this thesis.

One approach to reducing water consumption is to design a wastewater treatment and recycling system. These pre-treated water can be used for toilets' flushing, irrigation, fire control, and cooling systems since potable water consumption is only a tiny part of the total water consumed by an airport. By taking these measurements, Western Sydney Airport can reduce its water consumption to a satisfactory level.

It is introduced that there are two primary types of wastewater generated at the airport. One type is wastewater generated by passengers at the airport, and the other is wastewater generated by the operation and maintenance of the airport. Since the dominant pollutants in these two types of wastewater are different, they should be treated separately. The activated sludge process is chosen for wastewater generated by passengers, and biofilter is chosen for wastewater generated by the operation and maintenance of the airport.

When estimating daily water consumption, the estimated data is based on the predicted daily passengers in 2060. The number of estimated annual passengers is 82,000,000, and the annual water consumption is 2,460,000,000 L. The daily wastewater generated by passengers is 6,740,000.

The number of estimated busy hour passengers is 18,700, and the total wastewater generated by passengers on busy days is 9,541,667 L per day.

The design capacity of the ASP should consider the peak flow of wastewater. Thus, it is designed to have a capacity of 10,000,000 L.

For the estimation of wastewater generated by the operation and maintenance of the airport, since there is no direct data about the consumption, the estimation was calculated based on the proportion of water consumed by passengers. The average percentage of water consumed by passengers contribute to the total water consumption is 20%. Then the wastewater generated by the operation and maintenance of the airport is calculated as 40,000,000 L per day in the busy period.

The design capacity of the biofilters is 40,000,000 L.

The estimation method used in the thesis has many limitations. It cannot give an accurate design capacity. When doing further study, the water consumption data of Western Sydney Airport should be used to determine the design capacity of wastewater treatment and recycling systems.

6. Executive summary

There is an increasing demand for aviation services, but the aviation capacity of Sydney Airport is not enough to meet the increasing demand. A new airport which is located in Western Sydney, is underway. Much research shows that the water consumption of airports is enormous. Thus, it is essential for an airport to design a water management system. This thesis aims to design a wastewater treatment and recycling system to reduce the water consumption of Western Sydney Airport. The first part of this thesis is a literature review that talks about the basic information of Western Sydney Airport, including why there is a need for a new airport, activity forecasts. Then, different types of wastewaters generated by an airport will be introduced with their specific treatment approach. The necessity of building a wastewater treatment and recycling system will be mentioned. Then the wastewater recycling system will be introduced, and some water-saving measurements taken by other airports will be discussed. The second part is about the detailed calculation of the maximum capacity of the wastewater treatment and recycling system. The capacity of the wastewater treatment system is primarily determined by the peak flow of total wastewater generated by the airports. The third part is the outcomes and discussion, which will discuss the limitations and any improvements. The critical findings of this thesis will be mentioned with the calculation results. Some recommendations about how to keep the efficiency of wastewater treatment facilities are mentioned in the discussion part. There is a conclusion that will summarize all critical findings of the thesis and show the final design capacity of the two wastewater treatment processes separately.

Acknowledgments

I would like to extend my sincere thanks to my demonstrator Noor Baktash and the course coordinator Robert Holdom. They gave valuable advice and practical suggestions to my thesis.

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