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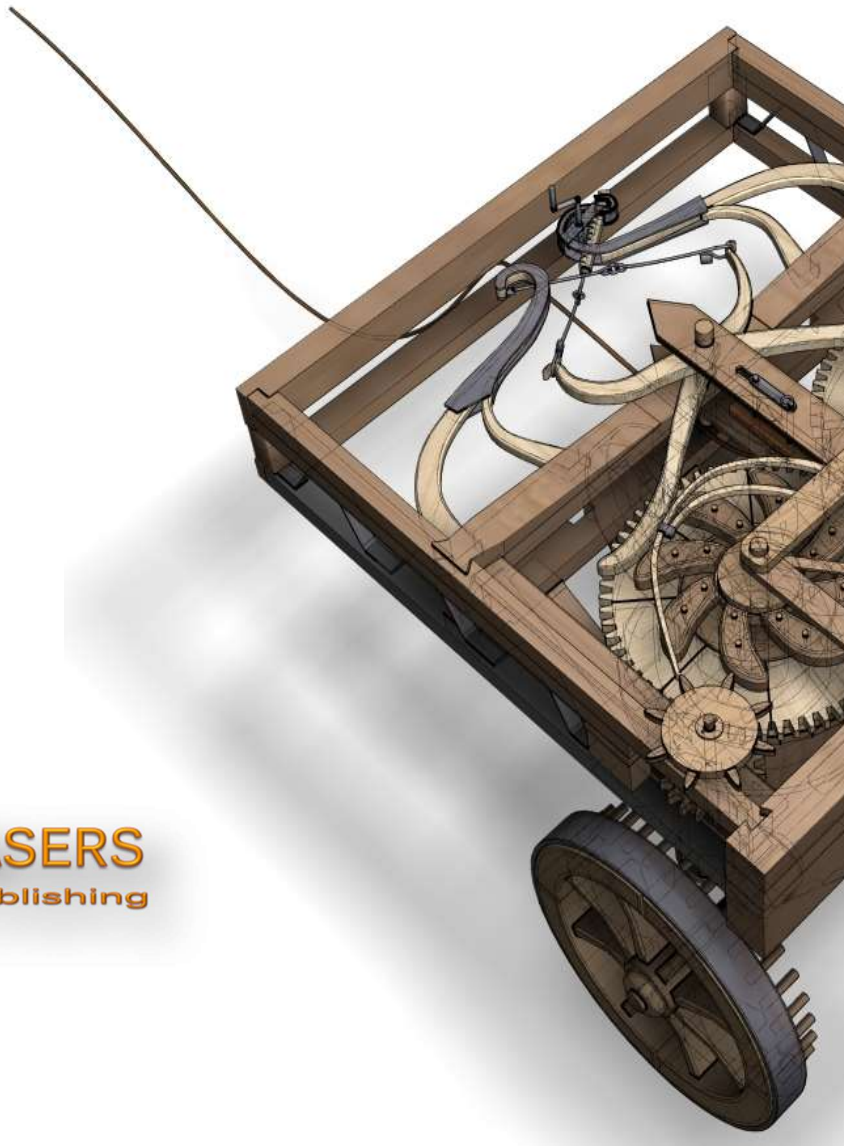

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Analysis of Sea and River Water Quality Standards Due to Operations and Domestic Activities in the Sanur Port Area, Bali

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Abstract: The development of an area has impacts, both positive and negative impacts. The positive impact is in the form of regional economic growth, employment and development of the surrounding regions. The negative impact is the disruption of the environmental ecosystem and a decrease in environmental quality due to waste generated from development operations, in the form of solid waste (garbage) and liquid waste. The increasing pollution load is also caused by public awareness and business activities in upstream areas that do not manage waste properly, which ultimately leads to all of the waste accumulating in water bodies and causing changes in water quality standards. Sanur Port, which is one of the development centers in its operations, is very vulnerable to environmental pollution impacts. The pollution mechanism originates from activities around Sanur Port and domestic activities which are discharged into rivers and seas in the Sanur area. This research aims to analyze the quality of river water and sea water caused by activities around Sanur Port and community activities based on Decree of the Minister of Environment Number 51 of 2004 and determine the pollution index. Water quality standards use Bali Governor Regulation no. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage. This research uses a quantitative approach by collecting primary data from direct observations in the field and secondary data based on previous research reports and government reports. The research results show that TDS in the rainy season tends to be lower than in the dry season, both in the results of testing samples of Abianbase river water, the results of testing samples of sea water in front of the Mak Beng Restaurant and sea water samples in the Sanur Port Pool. In front of Mak Beng, ammonia levels during the rainy season are higher than during the dry season. Ammonia levels in the Abianbase River and sea water in front of Sanur port are lower during the rainy season compared to the dry season. The presence of Coliform bacteria and E. coli shows a tendency to decrease during the rainy season. This decrease is thought to be caused by leaching by rainwater entering marine waters and retailing and changes in ocean currents during the rainy season.

Keyword: pollution; waste; quality; water; environment.
JEL Classification: Q01; Q5; Q56; R11.

Introduction

Although ports have an economic impact, they also have a negative impact on the environment. The port industry is one of the fastest growing sectors that causes environmental pollution. Some specifications such as labor intensity, contribution to economic growth, connections, and relationships with cities result in different levels of social and economic sustainability compared to other industries. Ports are economic engines and trade gateways due to their unique position in the shipping supply chain between different modes of transportation. There are many stops at ports along inter-island ships' journeys which can have an impact on the economy and tourism on the island of Bali. One of the ports built in the Sanur area of Denpasar City, Bali is Sanur Port. Sanur Port is influenced by demands for supporting facilities for the main tourism activities and ferry activities. The distribution pattern of tourism facilities on Sanur Beach forms a linear pattern towards the footpath, with land use density towards the south of the Sanur Beach area (Sylvan *et al.* 2015). So far, Sanur Port operations have increased the pollution load due to the impact of human activities and domestic community activities (Sudipa et al, 2020). Sanur Port operations also have an impact due to waste generation which requires sustainable management (Armadi *et al.* 2020). Sanur Port operations have put pressure on the physical environment, especially water quality and other domestic activities. Therefore, establishing policies that consider equity, efficiency and sustainability is the main target for decision makers in port environmental management (Nikoo *et al.* 2013). Furthermore (Lassard *et al.* 2013) explained that human activities greatly influence water quality and water quantity. Reservoir water quality is greatly influenced by the topography and patterns of spatial use and use of an area. Uncontrolled discharge of domestic and agricultural wastewater will affect the quality of sea water and river water (Tang et al, 2012). Increased domestic activities and tourism have an impact on the environment, especially on water quality. Various activities at Sanur Port, tourism and domestic activities can reduce the quality of the environment around Sanur Port (Dian *et al.* 2020).

The decline in water quality is not only caused by industrial waste, but also caused by household waste, both liquid waste and solid waste. The decline in water quality is caused by pollution from household waste and industrial waste which does not comply with the rules for proper waste disposal and processing regarding the conditions of the surrounding environment, thus having an impact on the condition of river water and ground water (Supardiono *et al.* 2021). The life of aquatic organisms is closely related to water quality both physically and chemically, as well as biologically. Water quality parameters are influenced by land use and the intensity of human activities in the surrounding area. (Nida *et al.* 2023). Waste resulting from socio-economic processes must be carefully monitored by the government because cultivation activities can reduce water quality (Ozdemir *et al.* 2014). Sea and river water pollution around Sanur Port originates from several activities, including: residents, agriculture and livestock. Potential pollutants that can pollute reservoirs are in the form of solids and/or liquids (Brahmana *et al.* 2010). This research aims to analyze the status of water quality due to water pollution. The research method uses a quantitative approach by taking sea and river water samples to determine the physical, chemical and biological parameters of water using purposive sampling which is differentiated based on distance. The research was conducted in September 2023 – February 2024.

1. Literature Review

1.1 Sanur Port

The main port as a port with the main function of serving domestic and international sea transportation activities, transshipment of domestic and international sea transportation in large quantities as well as ferry transportation with service coverage between provinces. A collecting port is a port with the main function of serving domestic sea transportation activities, transshipment of medium volume domestic and international sea transportation as well as ferry transportation with service coverage between provinces. Meanwhile, feeder ports are ports whose main function is to serve domestic sea transportation activities, transshipment of limited sea transportation, and are feeders for main ports and collecting ports as well as ferry transportation with service coverage within the province (Yolanda, 2023).

Considerations for choosing a location in the Matahari Terbit Beach area in Sanur are based on considerations of the spatial zoning of Denpasar City, the absence of distribution of live coral in the sea area. According to Logan *et al*. (2023), sediment in the Sanur area moves parallel to the coastline from north to south to Matahari Terbit Beach and sediment moves parallel to the coastline from south to north to Sanur Beach. Because there was no significant erosion, it was concluded that the construction of Sanur Port did not affect tourism activities in the Sanur area.

1.1 Water Pollution

The decline in water quality is not only caused by industrial waste, but also caused by household waste, both liquid waste and solid waste. Cases of decreasing water quality have occurred in several regions of Indonesia. The decline in water quality is caused by pollution from household waste and industrial waste which does not comply with the rules for proper waste disposal and processing regarding the conditions of the surrounding environment, thus having an impact on the condition of residents' well water, river water and ground water (Puspa *et al.* 2023).

The life of aquatic organisms is closely related to water quality both physically and chemically, as well as biologically. Water quality parameters are influenced by land use and the intensity of human activities in the surrounding area. (Yolanda *et al.* 2023). Various community activities around rivers and seas have not only caused environmental damage in the form of changes in landforms, landscapes and conservation areas, it is even suspected that the impact of pollution on the environment is caused by uncontrolled disposal of waste or rubbish. As a result of the activities carried out by the community, of course, this causes additional material to be added to the river. Adding material to the waters will affect the conditions of the waters both biologically, physically and chemically. Changes in water content are determined by the content of chemical compounds and materials that enter a body of water and are an important factor in studying the development of aquatic communities (Fernandez *et al.* 2023).

Currently, humans lack environmental awareness, many of them do not understand environmental cleanliness, so they easily create household waste, both liquid and solid, in the form of rubbish which is very dangerous for the environment. Just like the daily activities that we do, such as bathing, washing and various other activities that we consider trivial but which produce residual waste can actually be harmful to humans and the environment, especially the marine environment. Of the many human activities, it turns out that the most dangerous is household waste. Even though we don't live in a coastal area and a lot of untreated industrial waste can also harm marine waters, look at the large number of Indonesians with untreated household waste that is produced every day. It can be said that the damage caused by household waste is greater than industrial waste (Razi *et al.* 2023).

The construction and operation of Sanur Port has had an impact on pollution of the waters around Sanur Port, both from solid waste and liquid waste. The water quality status needs to be re-examined to see whether it shows a polluted condition or a good condition by comparing the water quality standards set to prevent water pollution due to the introduction of living creatures, substances, energy and/or other components into the water by human activities, so that the water quality drops to a certain level that causes water to not function according to its intended purpose (Yulianto *et al.* 2023). Land use at Sanur Beach is influenced by demands for supporting facilities for the main tourism activities and crossing activities. The distribution pattern of tourism facilities on Sanur Beach forms a linear pattern towards the footpath, with land use density towards the south of the Sanur Beach area (Safira *et al.* 2023).

Sanur Port and the surrounding area have complex conditions in terms of utilization, namely use for tourism, use for the economy, and use for religious rituals including socio-cultural interactions within it which can cause conflict and pressure on the physical environment. The cases that occurred at similar ports were not as complex as those at Sanur Port, especially the interaction of tourism and socio-culture in religious spaces such as at Sanur Port.

1.3 Environmental Management

Environmental management is a very important thing to do, considering that humans always try to maximize the realization of all their desires and often in the fastest way possible, so they tend to sacrifice the interests of their environment. Sustainable environmental management will influence the availability of water resources, food and energy security to support the achievement of sustainable development goals (SDGs). Environmentally friendly agriculture, efficient use of water and efficient use of energy will ensure environmental sustainability (Muninggar *et al.* 2023).

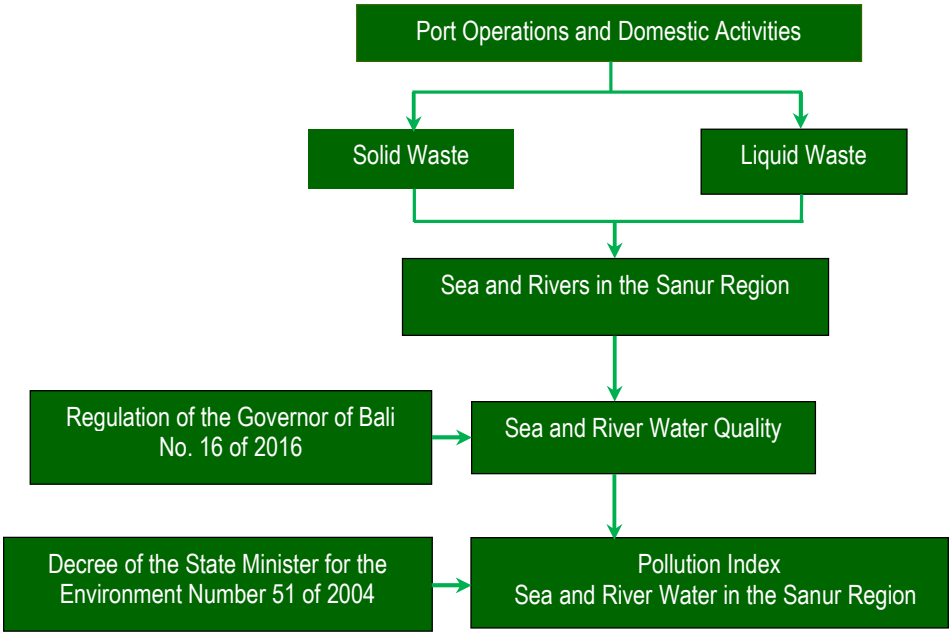
Good environmental management can be realized if the raw materials supporting production use environmentally friendly materials that can be quickly degraded by the environment and production development is able to reduce environmental pollution. The community has relevant power in environmental management. Community forces cause environmental changes which include four things, namely changes in science and technology, changes in government policies, changes in markets and the economy, and changes in public behavior (Juliansyah 2023).

Environmental management needs serious attention because it is a sensitive global issue that has the potential to cause negative impacts. To see environmental management performance, this can be done through evaluating environmental management performance which consists of implementing environmental impact analysis, controlling water pollution, controlling air pollution and greenhouse gas emissions, controlling solid waste, and managing liquid waste (Ahmad *et al.* 2022). Community participation is something that is absolute in the framework of creating a healthy living environment. There is a misunderstanding regarding community participation in environmental issues. Every human being, either directly or indirectly, is responsible for the sustainability of the environment (Rijulvita *et al.* 2023).

2. Research Methodology

The quality of sea water and river water after the operation of Sanur Port has a close relationship with various activities around the port, such as business activities that have the potential to produce solid and liquid waste and the disposal of domestic, agricultural and industrial liquid waste. Which is upstream of Sanur Port. The research design used by researchers is to conduct an analysis of environmental pollution and damage, analyzing the level of pollution and damage to the aquatic environment around Sanur Port based on the quality standards regulated in Bali Governor Regulation No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage as presented in Figure 1.

Figure 1. Framework of Thought



Determination of pollution status is determined using the pollution index as stated in the Decree of the Minister of Environment Number 51 of 2004 as follows:

$$Plj = \sqrt{\frac{(\frac{Ci}{Lij})^2_M + (\frac{Ci}{Lij})^2_R}{2}}$$

Information:
Li : Water quality concentration for water quality standards for water use (j)
Ci : Water quality concentration from survey results
Pij : Pollution index for designation (j)
(Ci/ Lij)M : Ci/Lij Maximum
(Ci/ Lij)R : Ci/Lij Average

The status of water quality standards is stated as follows:
1. 0≤Plj≤1.0: According to quality standards (good condition)
2. 1.0<Plj<5.0: Lightly polluted water
3. 5.0<Plj≤10: Moderately polluted water
4. Plj>10: Heavily polluted

3. Research Result

3.1 Existing Conditions of Sea and River Water Quality Standards in the Sanur Region

To determine the existing condition of Sanur Port water quality, this is done by comparing the results of analysis of physical, chemical, and microbiological parameters of water quality from samples taken at several river and reservoir water sampling points with the applicable water quality criteria, namely referring to Bali Governor Regulation No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage. Sampling and laboratory analysis of water quality taken in the dry season, namely in October 2023 and in the rain season, namely February 2024, based on these regulations in this research as a comparison, Class I, II, III, or IV Water Quality Criteria are used as standards. River water quality and sea water quality standards use a standard approach for port use, tourism and maritime, and marine biota. The river water quality parameters can be seen in Table 1 and the sea water quality parameters for ports, tourism and maritime use, and marine biota can be seen in Table 2.

Table 1. River Water Quality Analysis Parameters

No	Parameters	Unit	Bali Governor Regulation No. 16 of 2016			
			Class 1	Class 2	Class 3	Class 4
A.	**Physics**					
1	Temperature	^{0}C	Deviation 3	Deviation 3	Deviation 3	Deviation 5
2	TDS	ppm	1000	1000	1000	2000
B.	**Chemistry**					
1	pH	ppm	6 - 9	6 - 9	6 - 9	5 - 9
2	Ba	ppm	1	(-)	(-)	(-)
3	Fe	ppm	0,3	(-)	(-)	(-)
4	Mn	ppm	0,1	(-)	(-)	(-)
5	Cu	ppm	0,02	0,02	0,02	0,02
6	Zn	ppm	0,05	0,05	0,05	2
7	Cr	ppm	0,05	0,05	0,05	1
8	Cd	ppm	0,01	0,01	0,01	0,01
9	Hg	ppm	0,001	0,002	0,002	0,005
10	Pb	ppm	0,03	0,03	0,03	1
11	As	ppm	0,05	1	1	1
12	Se	ppm	0,01	0,05	0,05	0,05
13	Ammonia (NH_3-N)	ppm	0,5	(-)	(-)	(-)
14	Nitrat (NO_3-N)	ppm	10	10	20	20
15	Nitrit (NO_2-N)	ppm	0,06	0,06	0,06	(-)
16	Detergent	ppm	0,2	0,2	1	5
C.	**Microbiology**					
1	Total coliform	MPN/100ml	1000	5000	10000	10000
2	Faecal coliform	MPN/100ml	100	1000	2000	2000

Source: Bali Governor Regulation No. 16 of 2016

Table 2. Sea Water Quality Analysis

No	Parameters	Unit	Result	Tourism & Recreation Quality Standard	Marine Biota Quality Standard
A.	**Physics**				
1	Temperature	^{0}C	27,00	26-30	Nature Coral ≥20 Mangrove ≥80 Seagrass ≥20
2	Smell		Odorless	Nature 3	Nature 3

No	Parameters	Unit	Result	Tourism & Recreation Quality Standard	Marine Biota Quality Standard
3	Turbidity	ppm SiO2	**7,84**	<0,01	<5
4	TDS	ppm	**25.002**	≤ 20	Coral ≥20 Mangrove ≥80 Seagrass ≥20
B.	**Chemistry**				
1	pH		7,84	6-8,5	7-8,5
2	Cu	ppm	<0,0153	0,008	0,008
3	Zn	ppm	<0,0075	0,002	0,05
4	Cr	ppm	<0,003	0,00004	0,005
5	Cd	ppm	<0,001	0,00002	0,001
6	Hg	ppm	<0,0005	≤ 0,0001	0,001
7	Pb	ppm	<0,0036	0,00002	0,008
8	As	ppm	<0,0003	0,0026	0,012
9	Se	ppm	<0,0006	0,00045	-
10	Ammoni (NH_3-N)	ppm	**0,091**	Nil	0,3
11	Nitrit (NO_2-N)	ppm	0,001	Nil	-
12	Detergent	ppm	<0,05	Nil	-
C.	**Microbiology**				
1	Total coliform	MPN/100ml	**9200**	1000	1000
2	Faecal coliform	MPN/100ml	**3500**	200	-

Source: Bali Governor Regulation No. 16 of 2016

The water samples taken were as follows:
1. Sea water sample in front of Mak Beng Restaurant;
2. Sea water samples in front of Sanur Port;
3. Sea water samples in the Sanur Port pool; And
4. Abianbase River water sample.

4. Discussion

The results of the quality test for physical, chemical, and microbiological parameters of water samples taken during the dry season are as follows:

4.1 Sea Water Sample in Front of Mak Beng Restaurant

From the results of the pollution index calculation, it shows that the quality of sea water in front of Mak Beng Restaurant is as follows:

- Designation of Tourism and Recreation quality standards with a pollution index value of 12.07, where the water is heavily polluted.
- Water allocation for marine biota with a pollution index value of 6.76, where the water is in a moderately polluted condition.

From the results of the pollution index analysis above, it shows that the designation of tourism and recreation water quality standards is influenced by physical parameters, namely turbidity and dissolved residue (TDS), chemical parameters, namely free ammonia (NH_3-N), and biological parameters, namely total coliforms and faecal coliforms.

4.2 Sea Water Samples in Front of Sanur Port

From the results of the pollution index calculation, it shows that the quality of sea water in front of Sanur Port is as follows:

- Destination of Tourism and Recreation quality standards with a pollution index value of 1.34, where the water is lightly polluted.
- Water allocation for marine biota with a pollution index value of 0.5, where the water is in good condition and meets quality standards for marine biota life.

From the results of the pollution index analysis above, it shows that the designation of tourism and recreation water quality standards is influenced by physical parameters, namely turbidity and dissolved residue (TDS), chemical parameters, namely free ammonia (NH_3-N), and biological parameters, namely total coliforms and faecal coliforms.

4.3 Sea Water Samples in the Sanur Port Pool

From the results of the pollution index calculation, it shows that the water quality of Sanur Port is 35.84, where the water in it is very bad or in a heavily polluted condition. From the results of the pollution index analysis above, it shows that the designation of port water quality standards is influenced by physical parameters, namely dissolved residue (TDS) and biological parameters, namely total coliforms and faecal coliforms.

4.4 Abianbase River Water Sample

From the results of the pollution index calculation, it shows that the water quality of the Abian Base River is as follows:

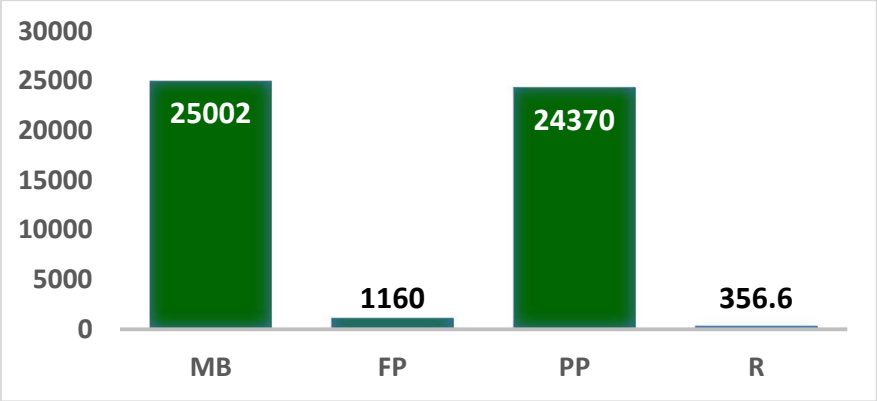
- Class I water designation with a pollution index value of 1.65, where the water is lightly polluted.
- Class II water designation with a pollution index value of 0.29, where the water is in good condition and meets quality standards.
- Class III water designation with a pollution index value of 0.20, where the water is in good condition and meets quality standards.
- Class IV water designation with a pollution index value of 0.13, where the water is in good condition and meets quality standards.

From the results of the pollution index analysis above, it shows that the designation of class I, II, III and IV water quality standards is influenced by biological parameters, namely total coliforms and faecal coliforms. From the results of the pollution index calculation above, several parameters that influence the water quality standards and pollution index in sea water in front of the Mak Beng Restaurant, sea water in front of Sanur Port, sea water in the Sanur Port pool, and Abianbase River water are explained as follows:

4.4.1 Dissolved Solids (TDS)

The parameter that influences water quality and pollution index is TDS. TDS is above the sea water quality standard limit, which can be seen in the results of testing sea water samples in front of the Mak Beng Restaurant and sea water samples in the Sanur Port Pool for use as quality standards for marine tourism and marine biota. Total dissolved solids (TDS) is quite high in the results of testing seawater samples in front of the Mak Beng Restaurant because of the run off of organic waste originating from activities in land areas that enter the water (Rinawati *et al.* 2016). The condition of the waters in front of the Mak Beng Restaurant is due to the presence of a fairly large water channel which flows quite rapidly carrying organic waste originating from domestic activities which causes organic and inorganic particles to flow into the waters (Wibowo *et al.* 2020). Almost the same condition occurs in sea water in the Sanur Weathering Pool, which is caused by the mouth of the Abianbase River entering the port pool and becoming trapped in the port pool. The results of the analysis of dissolved solids (TDS) parameters are presented in Figure 2.

Figure 2 Results of Dissolved Solids (TDS) Parameter Analysis

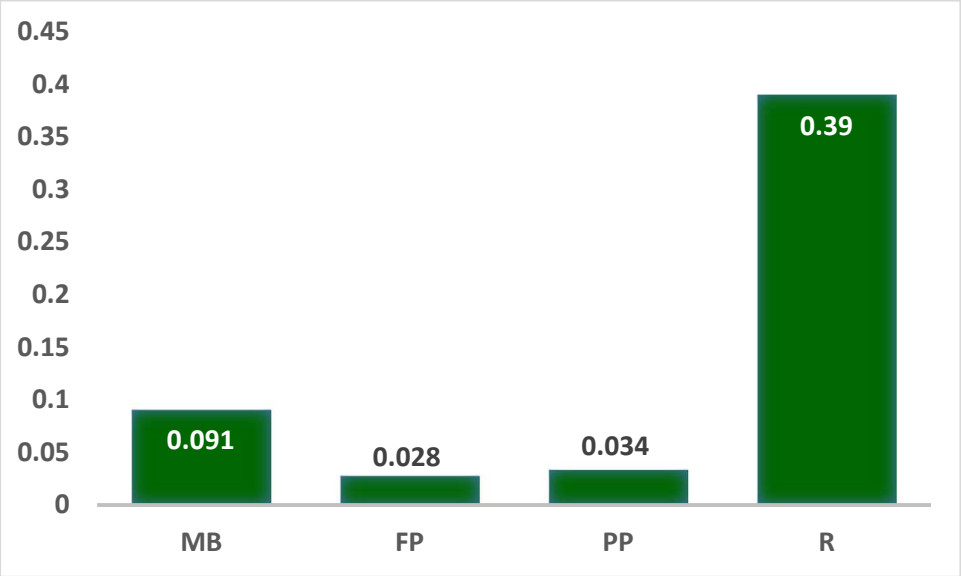


MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

4.4.2 Ammonia (NH_3)

Ammonia levels in sea waters on Sanur beach and its surroundings are caused by activities in upstream areas such as agriculture, accommodation and settlements which continuously enter the waters, accumulate and can become pollutants that disrupt the life of microorganisms in coastal waters (Putri *et al.* 2019). The highest nitrite concentration is found in the Abianbase River. Rivers and waterways are suppliers of ammonia into marine waters. This is because this area is densely packed with tourism, accommodation, restaurants and trade activities which are very close to the beach, causing organic waste, rubbish, human and animal waste to more easily enter the waters Widyastuti *et al.* (2015). The ammonia value is also related to the concentration of organic matter in a body of water (Hasibuan *et al.* 2017). This condition will increase pressure on the coastal environment. The results of the ammonia parameter analysis can be seen in Figure 3.

Figure 3. Results of Ammonia Parameter Analysis (NH_3)



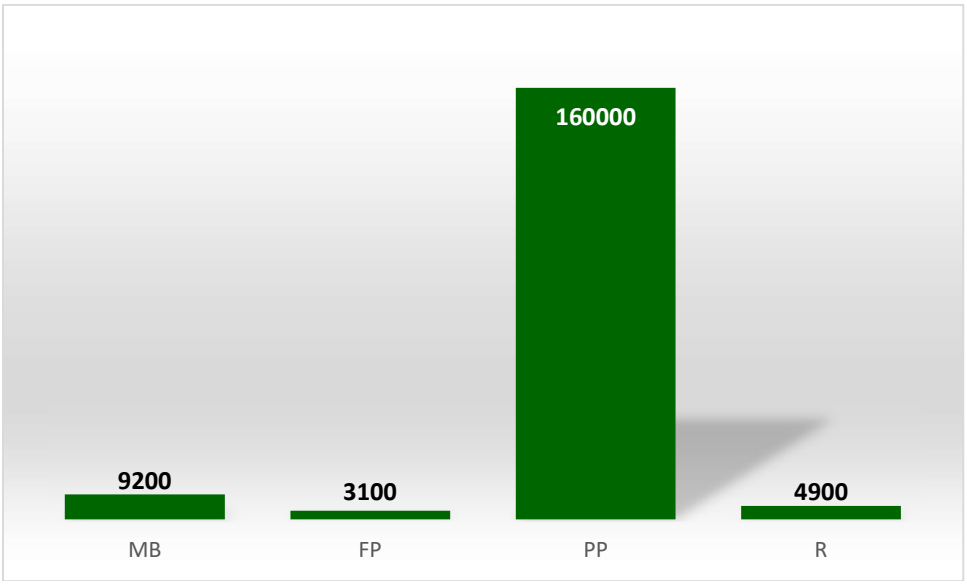
MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

4.4.3 Coliform and E-Coli

Under normal circumstances Coliforms and Escherichia Coli can grow in the digestive tract but can be pathogenic and can attack animals and humans in certain circumstances such as digestive disorders and immunosuppression in the host. Poor sanitation from livestock management results in Escherichia coli contamination, which is an environmental contaminant bacterium, namely environmental contamination bacteria (Mundi 2018).

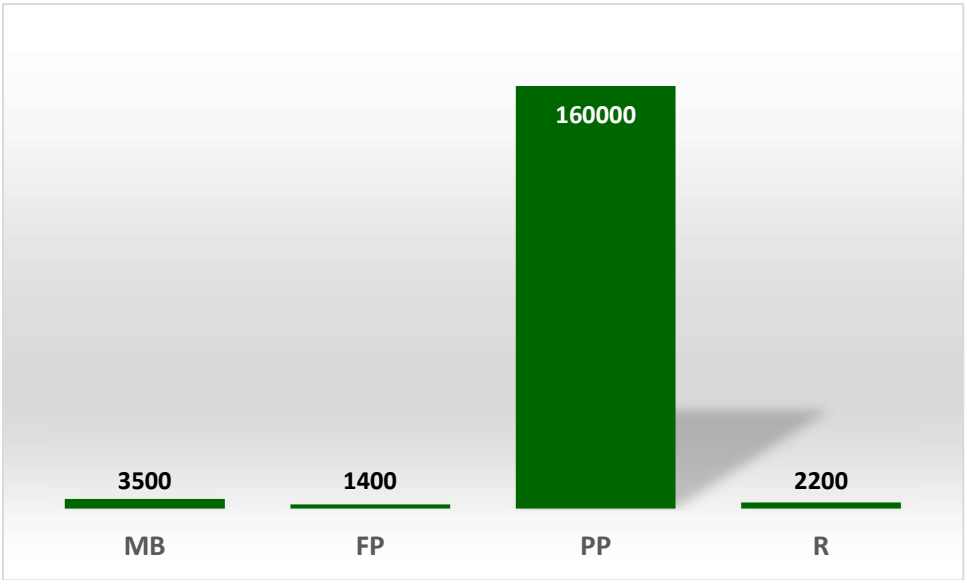
The presence of Coliform and E-Coli contamination bacteria can be thought to be caused by community activities that use spring water as a place to bathe and wash (Alam *et al.* 2016). Low community hygiene allows bacterial contamination. The existence of springs or rivers in city areas also allows many farms to enter the river or waterways which eventually enter sea waters and the possibility of poor sanitation which can increase feces deposits which can pollute river water. The highest e-coli parameters were in the Sanur Port pool, which was possibly caused by the accumulation of human waste material entering through the Abianbase River into the harbor pond which had an impact on the environmental health of Sanur Port causing the accumulation of pathogenic bacteria (Setiawan, 2013). The results of the analysis of coliform and e-coli parameters can be seen in figures 4 and 5.

Figure 4. Coliform Parameter Analysis Results



MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

Figure 5. E. Coli Parameter Analysis Results



MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

The results of the quality test for physical, chemical, and microbiological parameters of water samples taken during the rainy season are as follows:

4.5 Sea Water Sample in front of Mak Beng Restaurant

From the results of the pollution index calculation, it shows that the quality of sea water in front of Mak Beng Restaurant is as follows:

- Designation of Tourism and Recreation quality standards with a pollution index value of 10.7, where the water is heavily polluted.
- Water allocation for marine biota with a pollution index value of 5.9, where the water is in a moderately polluted condition.

From the results of the pollution index analysis above, it shows that the designation of tourism and recreation water quality standards is influenced by physical parameters, namely turbidity and dissolved residue (TDS), chemical parameters, namely free ammonia (NH3-N), and biological parameters, namely total coliforms and faecal coliforms.

4.6 Sea Water Samples in front of Sanur Port

From the results of the pollution index calculation, it shows that the quality of sea water in front of the Mk Beng Restaurant is as follows:

- Destination of Tourism and Recreation quality standards with a pollution index value of 0.84, where the water is in good condition and meets the quality standards for tourism and recreation.
- Water allocation for marine biota with a pollution index value of 0.38, where the water is in good condition and meets quality standards for marine biota life.

From the results of the pollution index analysis above, it shows that the designation of tourism and recreation water quality standards is influenced by physical parameters, namely turbidity and dissolved residue (TDS), chemical parameters, namely free ammonia (NH_3-N), and biological parameters, namely total coliforms and faecal coliforms.

4.7 Sea Water Samples in the Sanur Port Pool

From the results of the pollution index calculation, it shows that the water quality of Sanur Port is 21.64, where the water in it is very bad or in a heavily polluted condition. From the results of the pollution index analysis above, it shows that the designation of port water quality standards is influenced by physical parameters, namely dissolved residue (TDS) and microbiological parameters, namely Faecal Coloform.

4.8 Abianbase River Water Sample

From the results of the pollution index calculation, it shows that the water quality of the Abian Base River is as follows:

- Class I water designation with a pollution index value of 12.61, where the water is heavily polluted.
- Class II water designation with a pollution index value of 2.52, where the water is lightly polluted.
- Class III water designation with a pollution index value of 1.85, where the water is lightly polluted.
- Class IV water designation with a pollution index value of 0.54, where the water is in good condition and meets quality standards.

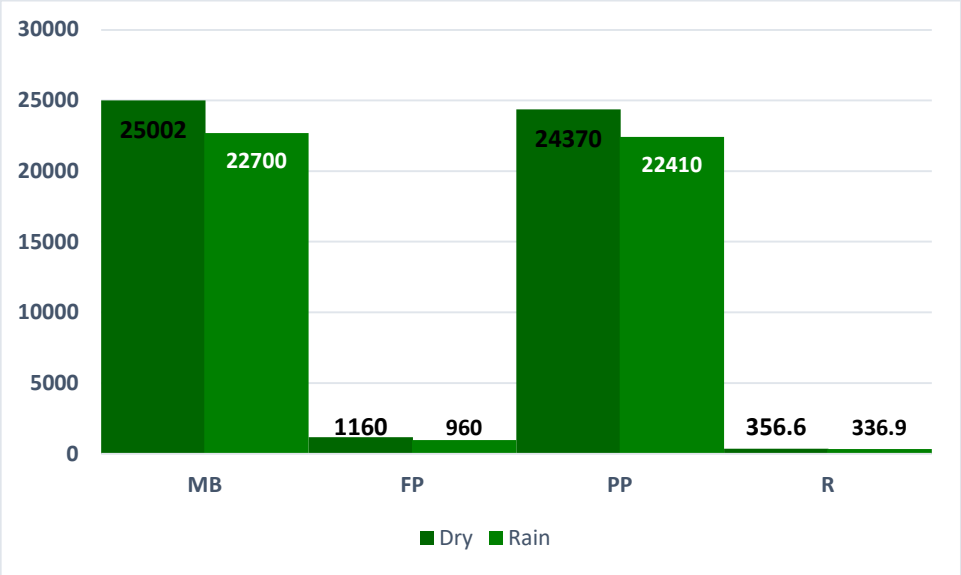
From the results of the pollution index analysis above, it shows that the designation of class I, II, III and IV water quality standards is influenced by biological parameters, namely total coliforms and faecal coliforms.

From the results of the pollution index calculation above, several parameters influence the water quality standards and pollution index in sea water in front of Maman Mak Beng's house, sea water in front of Sanur Port, sea water in the Sanur Port pool, and Abianbase River water both taken at during the dry season and the rainy season can be explained as follows:

4.8.1 Dissolved Solids (TDS)

The parameter that influences water quality and pollution index is TDS. When compared between the dry season and the rainy season, TDS in the rainy season tends to be lower than in the dry season, both in the results of testing Abianbase river water samples, the results of testing sea water samples in front of the Mak Beng Restaurant and sea water samples in the Sanur Port Pool. for the determination of quality standards for marine tourism and marine biota. The decrease in TDS parameters during the rainy season is probably caused by the intake of rainwater entering the waters and the retail process occurring continuously during the rainy season. A comparison of the results of analysis of dissolved solids (TDS) parameters taken during the dry season and rainy season is presented in Figure 6.

Figure 6. Results of Dissolved Solids (TDS) Parameter Analysis

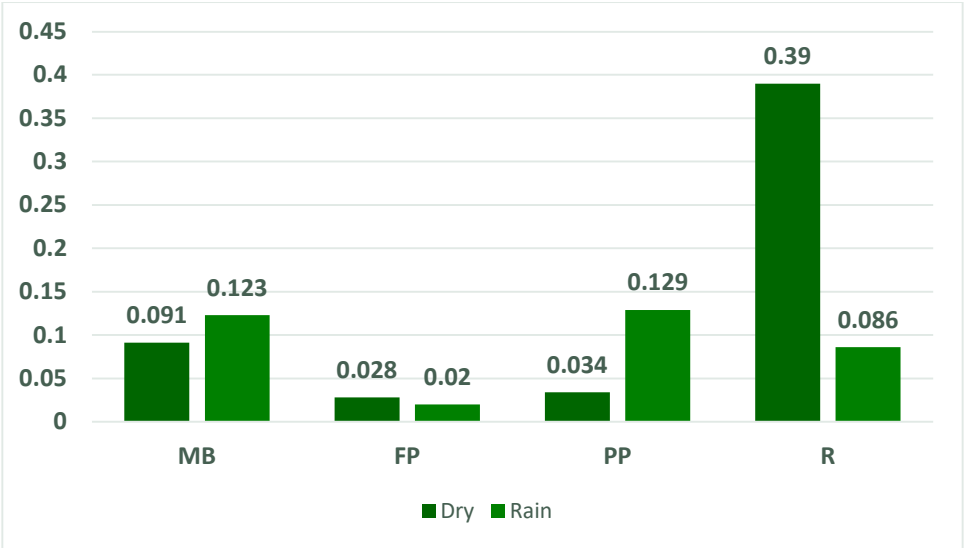


MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

4.8.2 Ammonia (NH_3)

Based on the results of the analysis of the Ammonia parameter (NH_3), the ammonia levels taken during the dry season and rainy season have different conditions. In front of Mak Beng, the ammonia level during the rainy season is higher than during the dry season, possibly due to waste from domestic activities flowing from the water channel in front of the beach which distributes ammonia from land which runs off during the rainy season and the same condition also occurs in the harbor pool water. Different water conditions can be seen in the Abianbase River and the sea water in front of Sanur Port which is lower during the rainy season compared to the dry season. This condition is caused by water runoff that enters the Abianbase River during the rainy season, which causes quite a lot of water to fall due to dilution and this condition also occurs in sea water in front of Sanur Port. A comparison of the results of ammonia parameter analysis during the dry season and rainy season can be seen in Figure 7.

Figure 7. Results of Ammonia Parameter Analysis (NH_3)

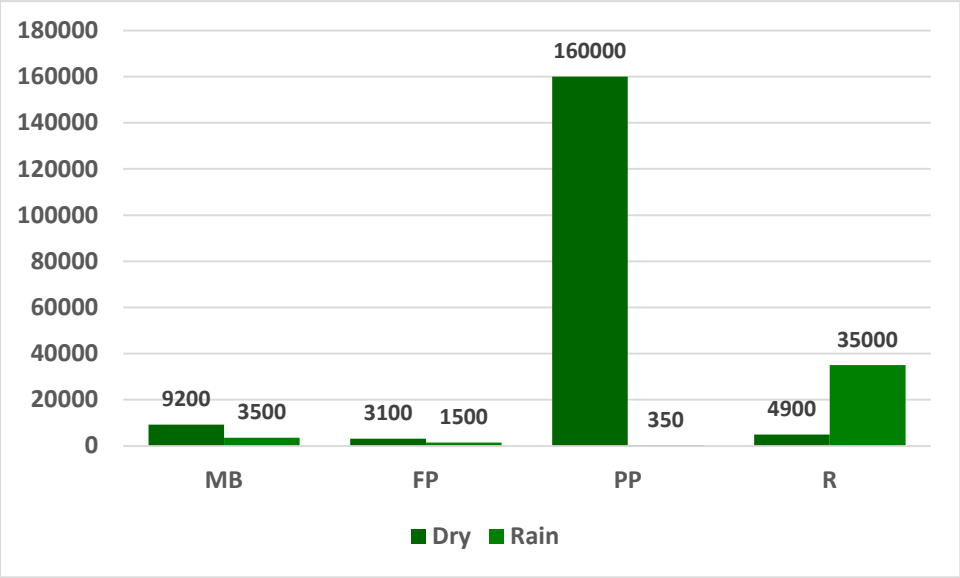


MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

4.8.3 Coliform and E-Coli

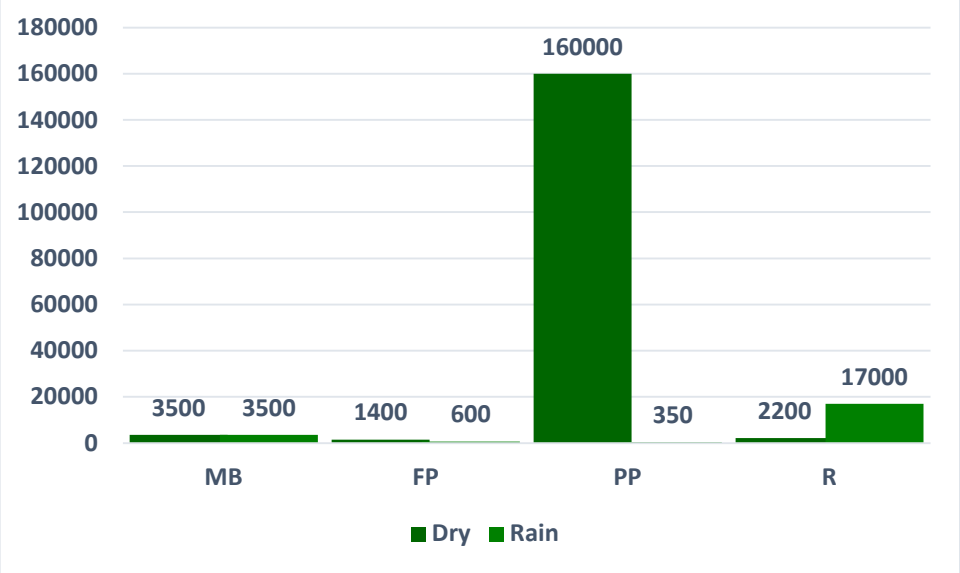
The presence of Coliform and E-Coli bacteria shows a tendency to decrease during the rainy season. This decrease is caused by leaching by rainwater that enters sea waters and retailing and changes in sea currents during the rainy season, including in the Sanur Port pool, there is a decrease caused by the entry of rainwater from the Abianbase River and from the Sanur Port environment so that there is sufficient retailing. High levels cause the harbor pool water to come out and be replaced with water from rainwater runoff and Abianbase River water. The increase in coliform and e-coli parameters in the Abianbase River is caused by the accumulation of organic material and waste from land areas in the Abianbase River. A comparison of the results of the analysis of coliform and e-coli parameters during the dry season and rainy season can be seen in figures 8 and 9.

Figure 8. Coliform Parameter Analysis Results



MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

Figure 9. E. Coli Parameter Analysis Results



MB: Mak Beng Restaurant, PF: Port Front, PP: Port Pool, R: River
Source: Analysis Result

Conclusion and Further Research Coliform

TDS in the rainy season tends to be lower than in the dry season, both in the results of testing samples of Abianbase river water, the results of testing samples of sea water in front of the Mak Beng Restaurant and sea

water samples in the Sanur Port Pool. Ammonia levels taken during the dry season and rainy season have different conditions. In front of Mak Beng, ammonia levels during the rainy season are higher than during the dry season. Ammonia levels in the Abianbase River and sea water in front of Sanur Port are lower during the rainy season compared to the dry season. The presence of Coliform bacteria and E. coli shows a tendency to decrease during the rainy season. This decrease is caused by washing by rainwater that enters marine waters and retailing and changes in ocean currents during the rainy season. Serious efforts are needed to overcome the impact of pollution entering river and sea waters in the Sanur Port area by implementing a comprehensive environmental management approach from upstream to downstream. It is very important to carry out further research to mitigate the impacts resulting from Sanur Port operations and their impact on Sanur tourism. The novelty of this research is the accumulation of waste entering Sanur Port and Sanur Beach, both from domestic waste and waste originating from Sanur Port activities, which is reviewed thoroughly and is an important part of a complex tourism area. The importance of this research is to determine the pollution conditions that occur during the operation of Sanur Port, which intersects with one of the tourism centers in Bali, and to mitigate and improve environmental conditions in the future.

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Credit Authorship Contribution Statement

I Gede Cipta Sudewa Atmaja: Creating research concepts and ideas, conducting field data excavation, formulating research methodology, collecting data, validating data, writing drafts, conducting analysis and funding
Made Sudiana Mahendra: Formulate research concepts and ideas, make writing corrections, review data and writing, control data analysis and writing.
I Wayan Nuarsa: pay close attention to data analysis and writing, assist in data validation, review and edit data and writing.
I Gusti Bagus Sila Darma: Assisted in data curation, reviewing writing, validating field data, formulating writing and visualization procedures.
Nyoman Sudipa: assisting in extracting field data, compiling writing using software, supervising sampling in the field, editing, assisting in drafting and administration.

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.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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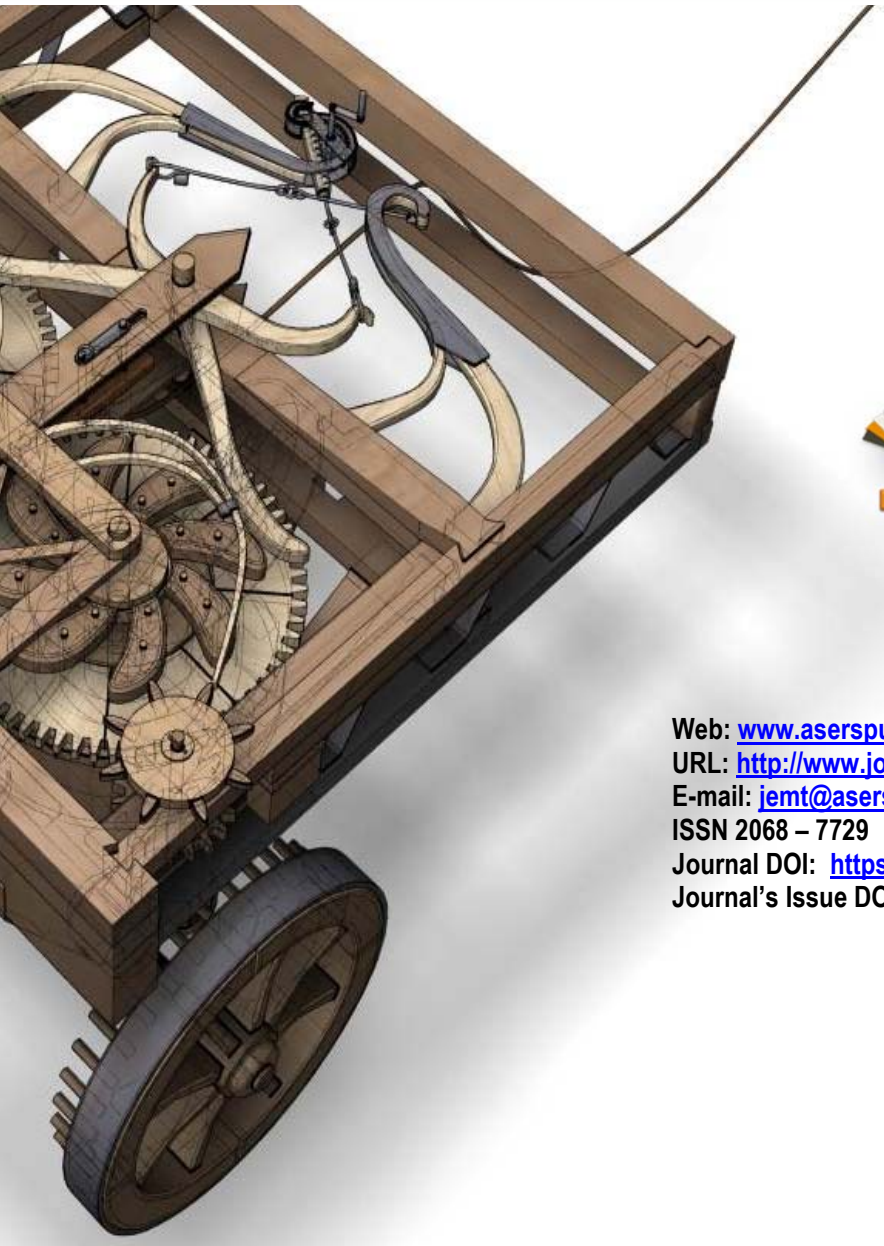

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