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Correlation of Changes in Waste Generation in the Year Before and During the Pandemic in Surakarta City

Mega Mutiara SARI
Faculty of Infrastructure Planning, Pertamina University, Indonesia
mega.ms@universitaspertamina.ac.id

Iva Yenis SEPTIARIVA
Faculty of Engineering, Sebelas Maret University, Indonesia
ivayenis@staff.uns.ac.id

I Wayan Koko SURYAWAN
Faculty of Infrastructure Planning, Pertamina University, Indonesia
i.suryawan@universitaspertamina.ac.id

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Abstract:

The city of Surakarta is one of the major cities in Indonesia that has been affected by COVID-19 with a high number of cases compared to cities in Central Java Province. The existence of COVID-19 not only has an impact on the health of the local community but also causes environmental problems. Therefore, to overcome these problems, a study was carried out on the effect of COVID-19 on changes in waste generation in Surakarta City. In this study, data were collected from local government inventory data, hypotheses, and data analysis using ANOVA. Based on the results of the study, it is known that the generation of domestic waste continues to increase during the pandemic, while the generation of waste in several public facilities such as transportation, parks, public places, and the Trade Office has decreased. The ANOVA analysis also shows that changes in the waste generation before and during the pandemic in Surakarta City were caused by changes in waste generation produced by domestic households and the government (Trade Department) while for other public facilities it did not affect these changes.

Keywords: waste management; Surakarta City; COVID-19; correlation.

JEL Classification: Q53; R11.

Introduction

The COVID-19 pandemic is one of the main problems that are being faced by all countries around the world. This pandemic has spread from 2019 to the present and has caused stagnation in various sectors such as the economy, tourism, and politics (Aratuo and Etienne 2019; Khalid, Okafor, and Burzynska 2021; Suryawan *et al.* 2021). To reduce the spread of COVID-19 cases in Indonesia, efforts and various policies have been carried out and implemented at various levels of Indonesian society. Doing self-quarantine, using masks when outside the house, maintaining a safe distance, maintaining a healthy body, washing hands after every activity, doing a COVID-19 test, limiting outdoor activities, and vaccinating are some examples of activities that must be obeyed by the community to reduce the spread of COVID-19 in Indonesia. However, the existence of these policies not only has a positive impact but also has several negative impacts that are felt by the community directly or indirectly. The existence of policies to limit activities causes humans to become more consumptive, causing an increase in the generation of

household waste. In addition, the need for personal protective equipment, cleaning equipment, and medical equipment causes the generation of hazardous waste to increase (https://www.unep.org/news-and-stories/press-release/waste-management-essential-public-service-fight-beat-covid-19). An increase in the amount of waste generated during this pandemic is not only a problem in one area but in all regions in Indonesia, one of which is Surakarta City.

Surakarta City is one of the cities located in Central Java Province with the potential of a close urbanization center. The Covid-19 pandemic has resulted in the order of life throughout the city of Surakarta (Abdurrohman, Arkasala, and Nurhidayah 2021). The dynamics that may occur in Surakarta City due to Covid-19 are the availability of food, sanitation, energy, education, and proper transportation. A pandemic as a disaster can be prevented and its impact minimized through planning and designing urban systems that can realize independence and resilience from disasters. It is very important to know the generation of waste to determine the facilities of each waste management unit and the capacity of equipment facilities, transportation vehicles, for example, transportation, recycling facilities, waste treatment, area and type of landfill and other management components (Bagus and Sumadiyanto 2020; Sari *et al.* 2022; Sarwono *et al.* 2021).

The increase in COVID-19 in Surakarta City in the early to mid-2021 was caused by the large number of people returning or leaving the city so that the spread of COVID-19 in the city became very massive. The high spread of COVID-19 in Surakarta City has caused the local government to tighten health protocol policies for the local community (Pramana, Utari, and Slamet 2021). As a result of this, medical waste has increased significantly, causing various environmental problems. Beside that medical waste in Surakarta City increased by 10% during the pandemic (Sunaryo 2021). The management of the waste generated during the pandemic and how to deal with the pandemic itself are the two main problems (Suryawan *et al.* 2021; Cordova *et al.* 2021; Vanapalli *et al.* 2021; Klemeš *et al.* 2020) that must be immediately faced by the City of Surakarta. Therefore, as a form of effort to overcome the waste problem in Surakarta City, this study analysis was carried out on how the correlation of changes in the waste generation before and during the COVID-19 pandemic in Surakarta City was carried out. The aim of this study is knowing the effect of COVID-19 on the amount of waste generated by the people of Surakarta City, it is hoped that the handling and management of waste during and after the COVID-19 pandemic can be carried out properly so that it does not cause various environmental problems in Surakarta City.

1. Methodology

The data used is inventory data from the environmental service of Surakarta City. This data was taken from January 2019 to December 2020. The data on waste generation was obtained which was transported from sources that were used as the dependent variable for transportation facilities, parks, the Trade Office (government), domestic, public places. While the independent variable is the total daily waste generation in Surakarta City. In this study, the hypotheses used to describe changes in waste generation in Surakarta City are:

H1: Due to restrictions on community activities during the pandemic, the use of public transportation has become much less than the pandemic and resulted in decreased waste generation in Surakarta City.

H2: Because people prefer to stay at home, the generation of waste generated in the city of Surakarta has decreased.

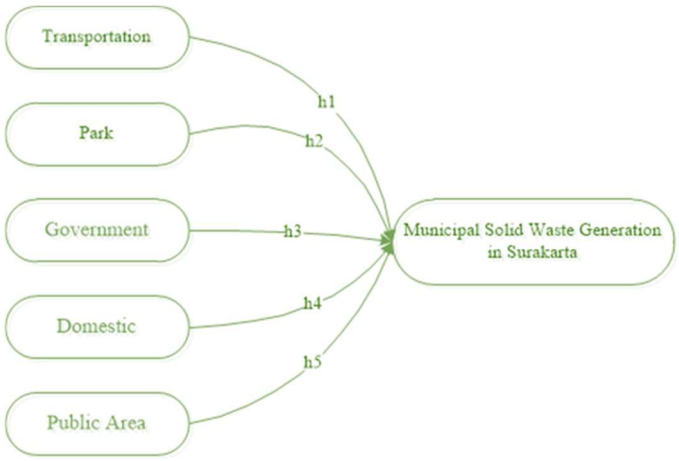
H3: Because public services continue to operate and activities still must run, it will result in the generation of waste in Surakarta City being constant or increasing.

H4: Because people tend to do activities at home, it will result in increased waste generation in Surakarta City.

H5: Due to restrictions on activities in public places, the waste generation in Surakarta City has decreased.

Briefly, the hypothesis can be seen in Figure 1. To show changes in waste generation at each location, time-series data processing is carried out where x is time while the y axis is the amount of waste generation for each location. Meanwhile, to see the relationship between each variable, the analysis of variance (analysis of variance, ANOVA) and multiple correlation coefficients were calculated.

Figure 1. The Hypothesis of the Correlation Framework for Waste Management in the City of Surakarta Before and During the COVID-19 Pandemic



2. Result and Discussion

In this study, data was collected on the amount of waste generation in Surakarta City before the pandemic took place in 2019 and during the 2020 pandemic as shown in Table 1 and Figure 1. Based on these data, it is known that waste generation in Surakarta City comes from transportation facilities, parks, The Department of Trade, domestic waste, and public places decreased on average from January 2019 to December 2019. However, a significant increase occurred in early 2020. This increase was due to the beginning of the COVID-19 pandemic that took place in Indonesia.

Table 1. Data on waste generation in Surakarta City (https://dlh.surakarta.go.id/new/?p=as&id=24)

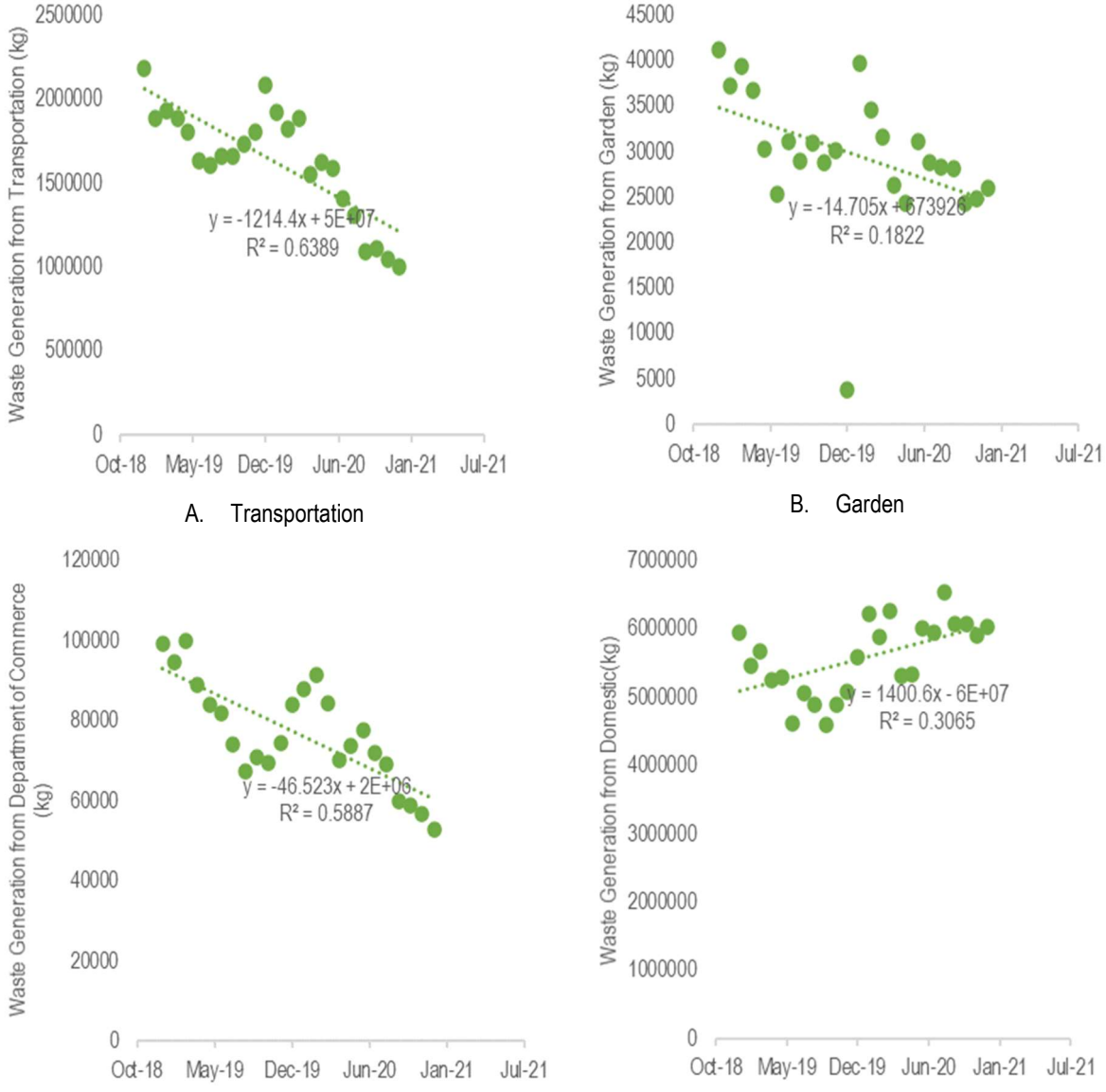
Time	Transportation (kg/month)	Garden (kg/month)	Department of Commerce (kg/month)	Domestic (kg/month)	Public Area (kg/month)	Avearage Waste Generation (kg/day)
Jan-19	2185150	41104	99128	5944400	1009150	340.033
Feb-19	1888350	37196	94428	5467760	915100	342.409
Mar-19	1933680	39369	99846	5671410	1454230	337.144
Apr-19	1885320	36694	88738	5251220	1040740	314.387
May-19	1800270	30252	83887	5286590	1100450	300.926
Jun-19	1628350	25333	81760	4605160	793540	269.933
Jul-19	1603800	31031	73965	5064950	1101520	284.524
Aug-19	1658000	28888	67450	4882450	1087800	277.149
Sep-19	1661810	30849	70743	4600610	963580	274.731
Oct-19	1734860	28737	69520	4896560	1087590	280.696
Nov-19	1800590	30171	74438	5079070	1102670	300.947
Dec-19	2085700	3756	83843	5579690	1192460	324.899
Jan-20	1922180	39733	87751	6217608	612220	323.447
Feb-20	1823340	34577	91250	5878219	588200	329.242
Mar-20	1881880	31570	84416	6253010	626130	320.028
Apr-20	1554670	26253	70127	5304580	484380	276.914
May-20	1626270	24362	73797	5340080	461790	271.282
Jun-20	1583670	31101	77624	6008650	679070	311.955
Jul-20	1407510	28842	72057	5936750	682780	291.485
Aug-20	1304810	28231	69119	6542950	573611	303.06
Sep-20	1088300	28112	59852	6060711	564200	286.428
Oct-20	1104460	24364	58753	6079751	536385	275.863
Nov-20	1046320	24808	56536	5907450	621251	279.615
Dec-20	1001420	25981	52647	6027890	521510	268.939

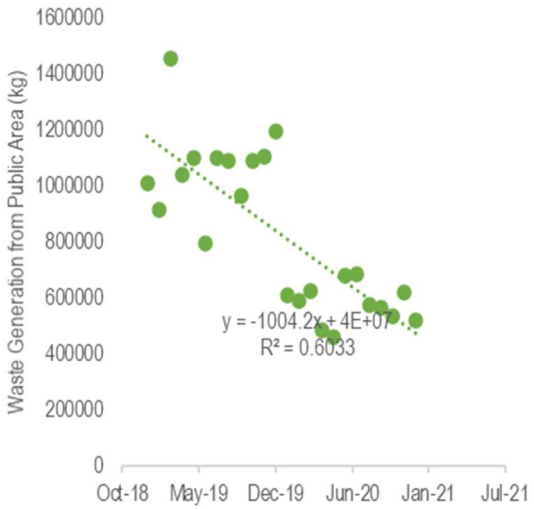
At the beginning of the COVID-19 pandemic, the consumption of health and hygiene equipment experienced a significant increase. In addition, consumption of household domestic products has also increased due to panic

buying that occurred in the community at the beginning of the COVID-19 pandemic (Sina 2020). Then from mid-2020 until the end of the year, there was a decrease in the amount of waste generation in some of these sectors. Data on waste generation in Surakarta City shows that household domestic waste contributes the most among waste elsewhere. The largest amount of waste is then obtained in transportation facilities, public places, the Trade Office, and parks. During the COVID-19 pandemic, the average domestic waste generation continues to increase every month. Before the COVID-19 pandemic occurred in Indonesia in February 2020, the amount of domestic waste generated in Surakarta City was 5,878,219 kg/month then it increased in the first month of the COVID-19 pandemic in March 2020 to 6,253,010 kg/month. Then in the following months there was an insignificant decrease and increase until in December 2020 the amount of domestic waste generation was recorded at 6,027,890 kg/month.

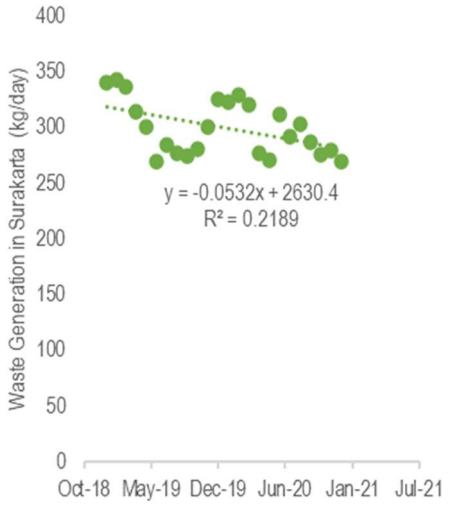
In transportation facilities in Surakarta City, the amount of waste generated from January 2019 to September 2019 continued to decline and an increase occurred from October to December 2019. Meanwhile, during the 2020 pandemic, the waste generated at transportation facilities continued to decline until December. 2020 waste generation generated is 1,001,420 kg/month.

Figure 2. Time series data on waste generation in Surakarta City from 2019-2020





E. Public Area



F. Overall Waste Generation in Surakarta

Then for the generation of waste generated in public places, parks, and the Trade Office also has the same trend as the amount of waste generated in transportation facilities. In general, the amount of waste generated in transportation facilities, parks, the Trade Office, and public places decreased during the pandemic period in 2020, while household domestic waste continued to increase during the pandemic. The decrease in waste in several public places was caused by the decrease in the number of visitors in these places due to government policies that urge people to continue doing activities at home (Ouhsine *et al.* 2020). On the other hand, the increase in the amount of household domestic waste generated is due to the high intensity of community activities carried out at home, such as switching between school activities and working from home (Sharma *et al.* 2020; Noviarini *et al.* 2022). Large-Scale Social Restrictions (PSBB) in several cities including Surakarta City as an effort to reduce the transmission rate of COVID-19 and the public's appeal to continue to carry out activities at home are the main factors for increasing domestic waste generation and decreasing waste generation in public facilities (Juwono and Diyanah 2021; Sari *et al.* 2022; Septiariva *et al.* 2022).

Sheth (2020) revealed that PSBB significantly disrupts consumer eating habits because it is bound by time and place. This change is also expected to have an impact on household consumption patterns. Online shopping activities have increased, especially by high-income people because of modern market restrictions and calls for activities (work/study) at home. This also significantly affects the increase in the amount of waste generated in the city of Surakarta. Another study also stated that the increase in the amount of waste during the pandemic occurred due to e-commerce shopping patterns that provide very tight packaging such as plastic (Sari *et al.* 2022; Septiariva *et al.* 2022; Sheth 2020; Tokar, Jensen and Williams 2021; Ebner and Iacovidou 2021; Parashar and Hait 2021; Escursell, Llorach-Massana and Roncero 2021). This increases the plastic problem in Indonesia and its use in the future (Zahra *et al.* 2022).

In addition to collecting data on waste generation in several places, this study also collects data on the amount of waste generated that is transported to the Waste Bank every day by cleaning staff in Surakarta City. Based on the data in Table 1 and Figure 1, the amount of waste generated from January 2019 to September 2019 decreased from 340.033 kg/day to 274.731 kg/day. Then the generation of transported waste increased from October 2019 to February 2020. Meanwhile, from the beginning of the COVID-19 pandemic in March 2020 until the end of 2020, the transportation of waste continued to decline. The COVID-19 pandemic has made it difficult for people to do activities outside their homes so that waste transportation is hampered and causes waste management to not be carried out properly.

In this study, the collected data was then carried out statistical analysis using ANOVA analysis. This analysis was conducted to determine the effect of solid waste generated in transportation facilities, parks, Department of Commerce, domestic, and public places on the average daily waste generation in Surakarta City. Based on the results of the analysis in Table 2, it is known that the regression results show a positive B value (30,533). This means that the independent variable has a positive effect on the dependent variable. Meanwhile, to determine the effect of each independent variable on the dependent variable, a comparison of significance analysis or t-count analysis was carried out on the t-table. From the results of the ANOVA, a significance value of more than 0.05 was found in the variables of transportation, parks, and public places, while for the domestic variable and the Trade Service, the significance value was less than 0.05. A significance value of less than 0.05 indicates that there is an

influence of the independent variable on the dependent variable. While a significance value of more than 0.05 indicates the existence of homogeneity or the absence of the influence of the independent variable on the dependent variable (Larson 2008). Therefore, based on ANOVA data, it is known that domestic waste generation and the Department of Trade affect changes in waste generation in Surakarta City, while transportation facilities, parks, and public places do not affect these changes.

Table 2. Coefficient Value and Significance of the Effect of Waste Generation on Various Sources on Average Daily Waste Generation in Surakarta City

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	30.533	24.761		1.233	0.233
	Transportation	1.389E-5	0.000	0.186	0.992	0.335
	Park	4.594E-5	0.000	0.014	0.167	0.869
	Goverment	0.001	0.000	0.569	2.955	0.008
	Domestic	2.589E-5	0.000	0.576	6.547	0.000
	Public Area	2.235E-5	0.000	0.254	2.657	0.016

The equation formed to obtain the average waste generation in Surkarta City can be seen in Equation 2.1. Where Y is the average waste generation (kg/day) in Surakarta City. X1 is waste generation in the transportation sector (kg/month), X2 is waste generation in the garden sector (kg/month), X3 is waste generation in the government sector (especially for the Department of Commerce) (kg/month), X4 is waste generation in the domestic sector, and X5 is the generation of waste in the public area (kg/month).

$$Y = 30.533 + 1.389E\text{-}5X_1 + 4.594E\text{-}5X_2 + 0.001X_3 + 2.589E\text{-}5X_4 + 2.235E\text{-}5X_5 \quad 2.1$$

Conclusion

Based on the results of the study, it can be concluded that the COVID-19 pandemic has caused various changes in waste generation in several public and domestic facilities in Surakarta City. Overall, domestic waste during the pandemic continued to increase compared to before the COVID-19 pandemic took place. Meanwhile, public places, transportation facilities, parks, and the Trade Office experienced a decrease in the amount of waste generated during the COVID-19 pandemic. An increase in household waste generation and a decrease in waste generation in several public facilities was caused by the reduced outdoor community activities during the pandemic. This study also performed statistical analysis using ANOVA. From the ANOVA analysis data, it is shown that changes in the waste generation before and during the COVID-19 pandemic in Surakarta City are influenced by the amount of waste generated by domestic waste and the Trade Office, while waste generation in transportation facilities, parks, and public places does not affect changes in waste generation. in Surakarta City during the COVID-19 pandemic.

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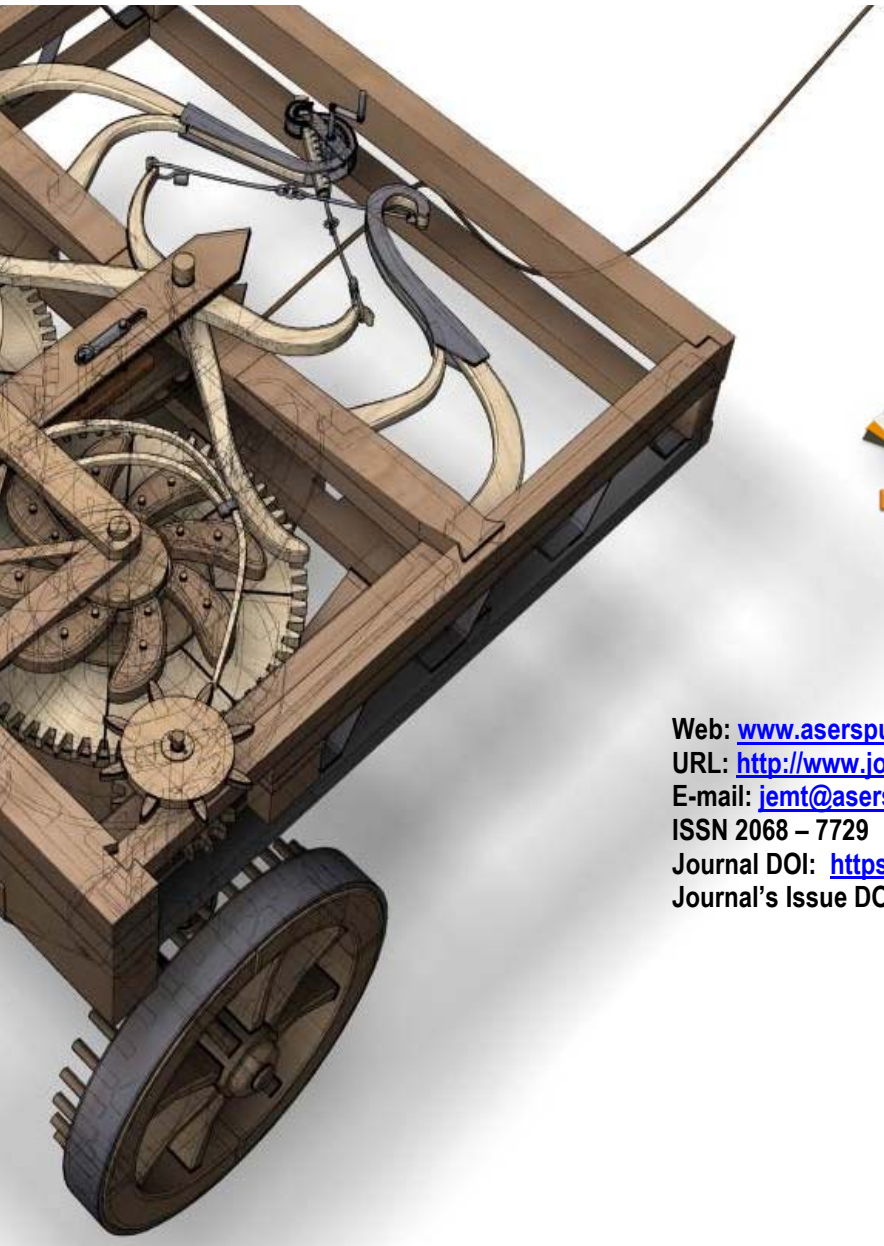

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