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Influence of Atmospheric Air Quality on the Morbidity of the Population Living in the Region of Oil and Gas Production in the Republic of Kazakhstan

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Abstract:

Sarkuland Kenkiyak settlements are located in the Aktobe province, at 18-20 km from the oil and gas producing field "Zhanazhol", in the northwest region of the Republic of Kazakhstan. To evaluate the exposure of the adult male and female population living in Sarkul and Kenkiyak settlements, a single medical study was conducted. The nonparametric method of the Spearman correlation analysis was performed between the mean concentration of substances exceeding the Maximum Permissible Concentration and the classes of newly diagnosed diseases. Selection and analysis of air samples was carried out according to the developed research protocol; the qualitative-quantitative analysis was carried out on the Gas analyzer HANK-4 apparatus. Significant pollution of atmospheric air by carbon monoxide, benzopyrene, dust and phenol were identified in places. Correlation dependencies between these pollutants of air and the diseases of the population revealed as a result of medical examination are established, as a result of diseases of the circulatory system, ear and mastoid process, nervous system and digestive organs; between the concentration of carbon monoxide and diseases of the circulatory system, the digestive system, the genitourinary system and the musculoskeletal system; between nitric oxide and diseases of the digestive system and the circulatory system; between benzopyrene and diseases of the digestive system, the genitourinary system and the nervous system.

Keywords: atmospheric air; public health; chemical substances; oil; gas.

JEL Classification: F64; K32; O13; P18; Q56.

Introduction

The oil and gas resource-extraction industries play an important role in improving the socio-economic conditions of the Republic of Kazakhstan especially for the producing administrative regions. Oil extraction in Kazakhstan produced an amount of 86.2 million tons in 2017 and 78 million tons in 2016. The petroleum potential is one of the highest in the geographic area of the Aktobe oblast (Region), where there are about 25 deposits. The mainstream geological find in this region is Zhanazholskaya deposit groups with about 170 million tons of oil reserves and condensates. The Zhanazhol deposit was opened in 1978 and exploitation started in 1984. The oil density is 0,818-0,858 g/cc, with a sulfur content less than 1%, sulfuric gums at 10% and asphaltenes at 0.59%. Methanoic gas, with hydrogen sulphide are the 6%. Condensate density is 0.75 g/cc. However, many environmental problems adversely affect the environmental and health conditions of people living in that area of production and transportation (Artemyeva 2010). The consequences of the use of environmentally hazardous technologies for oil and gas production during the five-year plans, the growth of man-caused load, the intensive exploitation of natural resources, the depletion of oil, gas, water, etc., have led to a progressive deterioration in the quality of the habitat, thus affecting the health of numerous oil-producing regions of the Republic Kazakhstan (Abikulova 2012, Alnazarova 2010).

Long-term supply of pollutants released by the oil and gas fields, as high-sulfur oils, and exacerbated by peculiar natural and climatic conditions, caused an increase in the degree of pollution of atmospheric air, natural waters, soil (Zinullin 2009, Nash 2006). It is well known that the human body reacts very sensitively to changes in the quality of the environment and climate and that the health status of the population can be regarded as important criterion for the quality of human habitat (Rana 2006, Rosner 2006). Even if the plasticity of protective-adaptive capabilities and adaptive reactions can preserve the body's homeostasis, a chronic increase in technogenic factors can cause overstraining and disruption of adaptation processes, with the subsequent development of the pathological processes: diseases of the circulatory system, diseases of the digestive system, diseases of the musculoskeletal system, musculoskeletal system diseases, diseases of the ear and mastoid process, diseases of the nervous system (Revich 2001, Wesselinova 2011, Levy and Nassetta 2011, Torres *et al.* 2018). Therefore, the need for studying health conditions of people under the influence of negative environmental factors connected to the oil and gas extraction becomes dramatically urgent.

1. Methodology

To the south of the oil and gas producing field "Zhanazhol" (Temir district, Republic of Kazakhstan), at a distance of 18-20 km, there are the villages Kenkiyak and Sarkol, with a population of 7513. The distance between the two villages is 6 km.

1.1 Patients

A single accurate medical examination on 181 adult male and 191 adult females living in the Sarkul and Kenkiyak villages was carried out.

The principle of patient selection was the exclusion criterion:

- men and women between the ages of 18 and 50;
- residing in these territories for at least 10 years;
- not having chronic diseases (not on the regular medical check-up of specialists in the place of residence).

To determine the sample size, the statistical program Sample XS was used. The error size was 5%; the default design effect is treated as 1.0.

The selection of participants in the study was carried out by random sampling in public places taking into account the age and sex composition of the population. Informed consent was collected from each participant. This research was approved by the ethical committee of the WKMO SMU (protocol No. 20 of 12.06.2017).

1.2 Outcome Ascertainment

The results of the medical examination of the population of the village of Sarkul and Kenkiyak were used. Functional methods of research of separate organs and systems were carried out, indicators of physical and somatometric development were estimated. Biochemical methods of blood tests, characteristics of the endocrinological status, functional methods of studying the cardiovascular system and respiratory organs were used.

The assessment of a comprehensive physical (arterial hypertension, heart rate), anthropometric indicators (height, weight, waist measurement) and laboratory (biochemical analysis of blood, general clinical analysis of blood, immunoassay of blood) examination of the population was conducted in expeditionary conditions with the participation of doctors of narrow specialties: therapist, cardiologist, endocrinologist, surgeon, otolaryngologist, obstetrician-gynecologist, dentist (Fareed 2016, Lee *et al.* 2014, Schooling *et al.* 2016, Duda *et al.* 2007).

1.3 Air Sampling

Qualitative and quantitative instrumental measurement of harmful substances in the atmospheric air of populated areas was carried out with the HANK-04 Gas Analyzer. The intake of atmospheric air was carried out 100 meters from the border of the settlement along the 4th rumba (north, east, south and west), considering the pressure, humidity, temperature, speed of air movement. As a result, the concentration of chemicals in the ambient air was determined. Samples were selected by the removable chemical cassettes for each ingredient. Selecting of samples was carried out for 10 seconds (3 times a day, the average number was taken from the result) for each substance with automatic indication of concentrations of harmful substances in atmospheric air (Universal gas analyzer).

1.4 Statistical Analysis

To statistically analyze the obtained data after patient evaluation and air sampling, the IBMSPSS Statistics 10.0 software was used. The results of the study are presented as percentage (%) $\pm$ standard deviation (SD). The nonparametric method of correlation analysis according to Spearman between indicators of the average substance concentration exceeding the MPC and classes of newly diagnosed diseases was conducted.

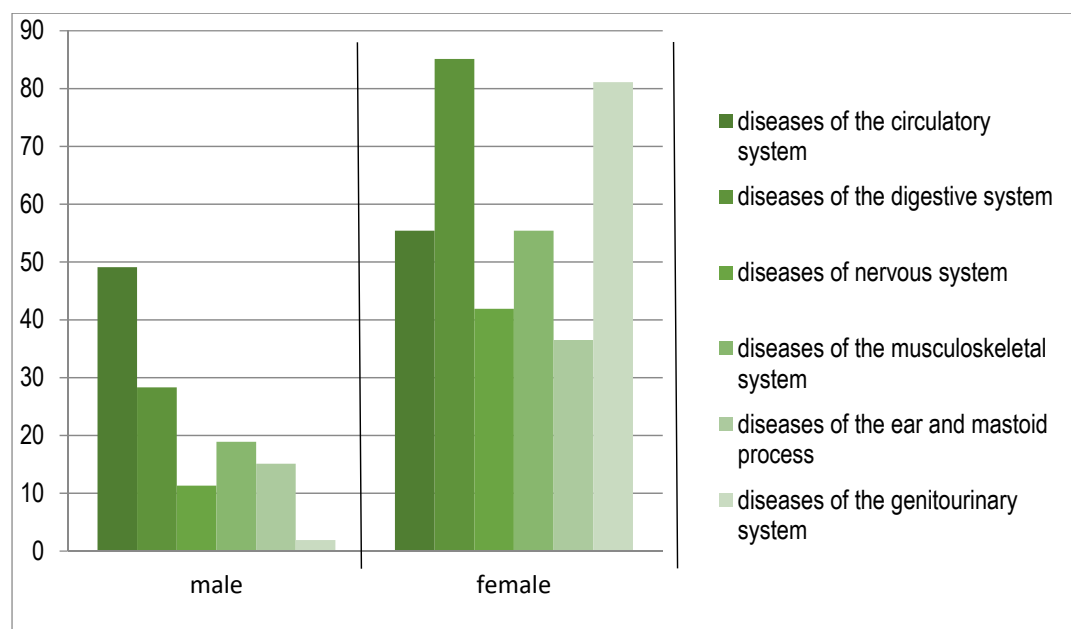
For qualitative indicators, which are not direct, but indirect, a nonparametric method of correlation analysis was performed. We selected the Spearman rank correlation, which is recommended to be used to evaluate the relationship between quantitative and/or ordinal characteristics. Correlated indicators are distinguished by the degree of reliability $p < 0.05$.

2. Results

2.1. Patient Examination

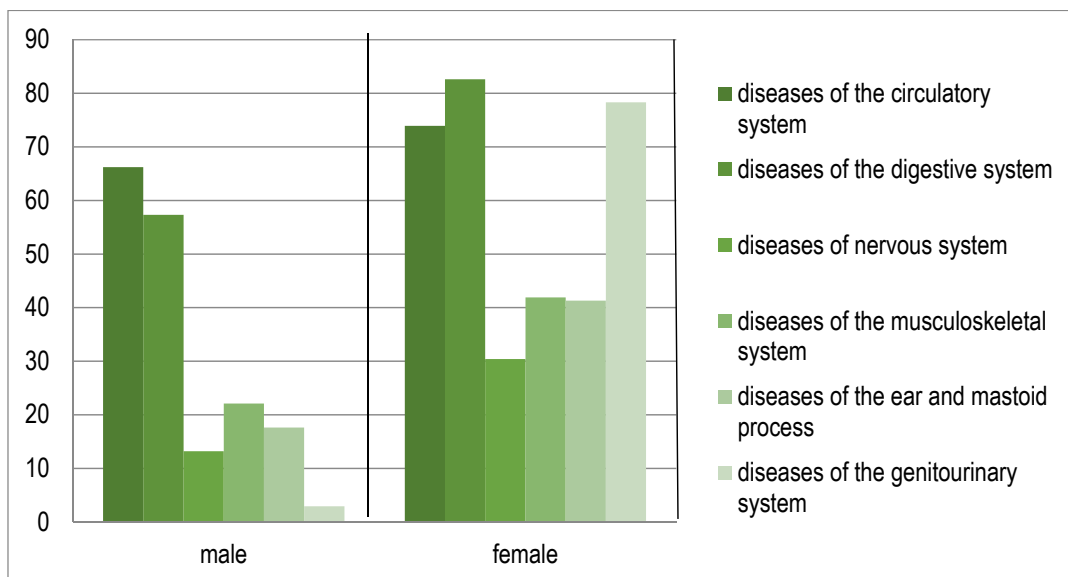
As a result of the frequency analysis of the medical examination made on the population living in Kenkyak village, the following distribution of classes of newly discovered nosologies in rank places was established among men: 1st: diseases of the circulatory system (49.1 ± 6.9), 2nd: diseases of the digestive system (28.3 ± 6.2), 3rd: diseases of the musculoskeletal system (1.9 ± 5.4), 4th: diseases of the ear and mastoid process (15.1 ± 4.9) and 5th: diseases of the nervous system (11.3 ± 4.4).

Figure 1. Percentages of major diseases detected among the surveyed resident of the village of Kenkyak (Kazakhstan)



Percentages increased among women living in the village of Kenkyak, with diseases of the digestive system ranking at the 1st place (85.1 ± 4.1), followed by those of the genitourinary system at the 2nd place (81.1 ± 4.6), diseases of the circulatory system at the 3rd place (55.4 ± 5.8), musculoskeletal system diseases at the 4th place (55.4 ± 5.8) and diseases of the nervous system at the 5th place (41.9 ± 5.7) (Figure 1).

Figure 2. Percentages of major diseases detected among the surveyed resident of the village of Sarkul (Kazakhstan)



In addition to the high incidence of newly diagnosed cases of diseases among women compared to men, the class of diseases classified according to ICD-10 classification was also high. The same first five classes of diseases were found between men and women but with a different ranking.

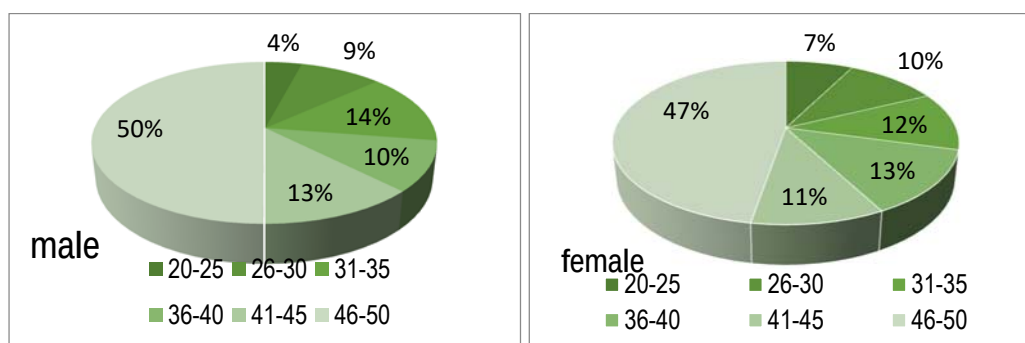
As a result of the frequency analysis of the medical examination of the population of the village of Sarkul, the following distribution of classes of newly discovered nosologies was established among men: at the 1st place, diseases of the circulatory system (66.2 ± 5.74), at the 2nd place, diseases of the digestive system (57.3 ± 6.02), 3rd place: diseases of the musculoskeletal system (22.1 ± 5.0), 4th place: diseases of the ear and mastoid process (17.6 ± 4.6), 5th place: diseases of the nervous system (13.2 ± 4.1).

Among women, diseases of the digestive system ranked at the 1st place (82.6 ± 5.59), while at the 2nd place, diseases of the genitourinary system (78.3 ± 6.1), at the 3rd place, diseases of the circulatory system (73.9 ± 6.78), 4th and 5th places: diseases of the ear and mastoid process and diseases of the musculoskeletal system (41.9 ± 5.7) (Figure 2).

Similarly, to what observed in the village of Kenkyak, also in Sarkul the women showed higher percentages of disease, respect to the man.

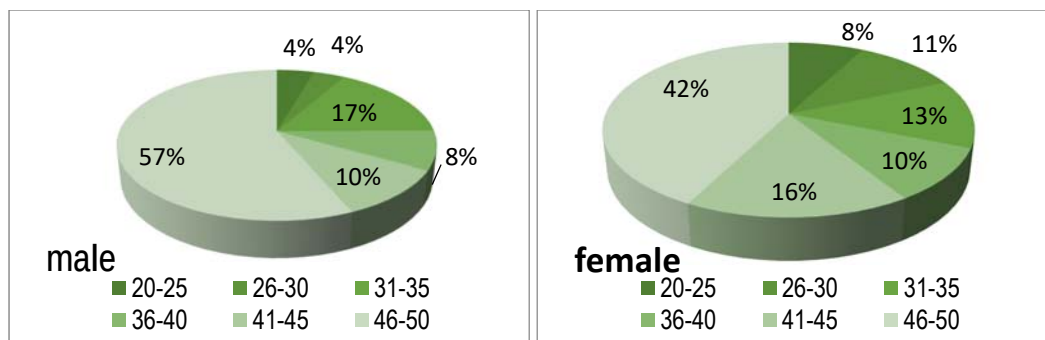
The age distribution of analyzed male patients in the Kenkyak village was as follow: 20-25 years: 4%; 26-30 years: 9%; 31-35 years: 14%; 36-40 years: 10%; 41-45 years: 13%; 46-50 years: 50%. Respectively, among women aged 20-25 years: 7%, 26-30 years: 10%; 31-35 years: 12%, 36-40 years: 13%; 41-45 years: 11%; 46-50 years: 47%. Morbidity was the 3% higher in women aged 46-50 and the 3% lower in the group aged 20-25 years (Figure 3).

Figure 3. Classification of the primary disease incidence in Kenkyak village according to age group



As a result of the distribution (classification) of the population of Sarkul with the newly diagnosed diseases by age categories, among men aged 20-25 years: 4%; 26-30 years: 4%; 31-35 years: 17%; 36-40 years: 8%; 41-45 years: 10%; 46-50 years: 57%. Respectively, among women aged 20-25 years: 8%; 26-30 years: 11%; 31-35 years: 13%; 36-40 years: 10%; 41-45 years: 16%; 46-50 years: 42%. The results showed that the morbidity of male population at the age of 46-50 is higher in comparison with female population on 5%, morbidity of male population at the age of 20-25 is lower in comparison with female population on 4%. As a result, for the two objects under consideration, the indicators tend to increase according to age (Figure 4).

Figure 4. Classification of the primary disease incidence in Sarkul village according to age group



2.2. Atmospheric Evaluation

The results of atmospheric air quality evaluations revealed different areas and levels of pollution of technogenic origin. Individual elements as nitrogen dioxide, sulfurous anhydride, hydrogen sulphide, mercaptan do were found at levels lower than the respective MPC. Differently, elements as benzopyrene (MPC-1mg/m³), carbon monoxide (MPC-5,0 mg/m³), dust (MPC-0,5 mg/m³) and phenol (MPC-0,035mg/m³) showed a significant increase, reaching dangerous values. Thus, carbon monoxide increased up to 3.5 over the MPC level, benzopyrene up to 13.3 MPC and dust up to 4.2 MPC-0,5 mg/Nm³. Elevated dust levels increased up to 3 MPC are observed throughout the Kenkiyak settlement, and in the southern part of the village the concentration of benzapyrene reaches 3.5 MPC.

The exceedances of MPC for phenol were detected (up to 1.5 MPC) at one of the points in the eastern part of the village of Sarkul.

The correlation between the atmospheric air pollution indices of populated areas was calculated between the mean concentration of the substance, the multiplicity of its maximum permissible concentration limit, the maximum one-time concentration, the percentage of samples exceeding the MPC, the concentration of the component from the PDCSS and the classes of newly diagnosed diseases. The degree of correlation between the studied quantities was determined according to these parameters. To assess the impact of air pollution on public health, ordinary indicators such as air dust, nitrogen oxides, carbon, benzapyrene and phenol were used (Table 1).

Table 1. The correlation between chemical air pollutants and the class of diseases identified

Classes of diseases	The magnitude of the correlation coefficient				
	dust	Carbon monoxide	oxide nitrogen	benzapyrene	phenol
Diseases of the circulatory system	0,7	0,6	0,6	-	-
Diseases of the ear and mastoid process	0,7	-	-	-	-
Diseases of the nervous system	0,6	-	-	0,4	-
Diseases of the digestive system	0,6	0,6	0,7	0,6	-
Musculoskeletal diseases	-	0,5	-	-	-
Diseases of the genitourinary system	-	0,6	-	0,6	-

«Development of scientific and methodological foundations for minimizing of the environmental load, medical support, social protection and health improvement of the environmentally unfavorable territories of the Republic of Kazakhstan»

The analysis showed that the most pronounced correlation between groups of diseases and average values of air dust content. Reliable correlations between air dust were observed in relation to the circulatory system illness ($r = 0.7$), ear and mastoid ($r = 0.7$) diseases, nervous system diseases ($r = 0.6$) and diseases of the digestive organs ($r = 0.6$). There was no correlation between dust and diseases of the musculoskeletal and genitourinary systems.

The increase in the concentration of carbon monoxide was associated with diseases of the circulatory system ($r = 0.6$), digestive system ($r = 0.6$), genitourinary system ($r = 0.6$), and to a lesser extent with diseases of the musculoskeletal system ($r = 0.5$). Any correlation was found between carbon monoxide and diseases of the ear and mastoid process and the nervous system.

Digestive organs ($r = 0.7$) and circulatory system ($r = 0.6$) diseases are correlated to nitric oxide, while with the rest of nosologies the correlation relation was not found.

The content of benzapyrene had a pronounced correlation with digestive system ($r = 0.6$) and genitourinary system ($r = 0.6$) diseases. Differently, a weak correlation was determined with diseases of the nervous system ($r = 0.4$). There

was no correlation between the diseases of the circulatory system, the ear and the mastoid process, the musculoskeletal system and benzopyrene.

The phenol did not correlate with any disease.

3. Discussion

If we take into account the fact that the medical examination was performed among healthy workers, these indicators are high. Low health indicators in turn may be one of the reasons for the underdevelopment of the local economy (Giannadaki *et al.* 2012) the most important role belongs to the quality of the environment and pollutants among the factors affecting health care expenditures. The findings of this study indicate that among the factors affecting health expenditures, environmental quality and contaminants played the most important role (Raeissi *et al.* 2018). Our results are consistent with the data of the work of Gusakova and co-authors (2017), stating that nitric oxide (NO), carbon monoxide (CO) and hydrogen sulfide (H₂S) are involved in the regulation of the functions of various organs and systems of the human body, including the circulatory system. In particular, the interaction of NO, CO and H₂S with various enzymatic and structural components of endothelial cells, especially smooth muscle cells, has a significant effect on the vascular tone and blood pressure (Gusakova *et al.* 2017). The above listed substances play an important role in the formation of morbidity and mortality rates (Lacressonniere *et al.* 2017).

Wesselinova (2011) observed a strong correlation between levels of air pollution and respiratory, cardiovascular diseases, various cancers and mortality. According to Levy and Nassetta (2011), in April 2010, an explosion on an oil rig in the Gulf of Mexico spilled about 185 million gallons of crude oil into the Persian Gulf. And when studying the adverse effects on workers' health, acute and chronic effects are established. Acute effects included respiratory, eye and skin symptoms, chronic effects included respiratory diseases, psychological disorders, genotoxic changes (Levy and Nassetta 2011, Torres *et al.* 2018). Pollution and the environment is a negative consequence of the development process, and many of the countries are fighting against this phenomenon (Raeissi *et al.* 2018). The literature describes the short-term effects of exposure, often manifested in the form of respiratory disorders (Adekola *et al.* 2017). The data on the effects of long-term effects in video-obstructive pulmonary disease and cancer pathology are also widespread (Ordinioha and Brisibe 2013, Colborn, Schultz and Herrick 2014). Thus, several scientists proved the negative influence of air pollutants on the health of the population living near sources. Therefore, measures are needed to prevent air pollution, monitor the state of the environment, and assess the risk to the health of the nearby population (Bari and Kindzierski 2018, Adgate, Goldstein and McKenzie 2014, Brown, Lewis and Weinberger 2015, McKenzie *et al.* 2012).

Conclusions

A certain dependence of the change in the health status of the population on the quality of atmospheric air can be seen at the local level despite the rather low level of risk of development of non-carcinogenic effects for public health in comparison with the established criterion. From the results obtained by analyzing the health status deviations of the population exposed to nitric oxide, carbon, benzopyrene, dust, and oil products and salts, and mainly associated with the chronic effects on the body, we can draw the following conclusions:

1. The following nosologies in rank places were identified as a result of the frequency analysis of the medical examination of the population of the village of Sarkul and Kenkiyak: 1st and 2nd place - diseases of the circulatory system for foraging of digestive organs; 3rd place - diseases of the genitourinary system, 4th place - diseases of the system and 5th place - diseases of the nervous system and diseases of the ear and mastoid process.

2. As a result of the distribution of the primary detected morbidity among the population of 20-50 years of age into 6 groups for the two objects under consideration, the indicators tend to increase.

3. Significant pollution of atmospheric air with carbon monoxide up to 3.5 MPC, benzopyrene up to 13.3 MPC, dust up to 4.2 MPC and phenol up to 1.5 MPC were identified by places.

4. The following were the correlation dependencies between air dust and diseases of the circulatory system ($r = 0,7$), ear and mastoid process ($r = 0,7$), nervous system ($r = 0,6$) and digestive organs ($r = 0,6$); between the concentration of carbon monoxide and diseases of the circulatory system ($r = 0,6$), digestive organs ($r = 0,6$), the genitourinary system ($r = 0,6$), and the musculoskeletal system ($r = 0,5$); between nitric oxide and diseases of the digestive system ($r = 0,7$) and the circulatory system ($r = 0,6$); between benzopyrene and diseases of the digestive system ($r = 0,6$), the genitourinary system ($r = 0,6$) and the nervous system ($r = 0,4$).

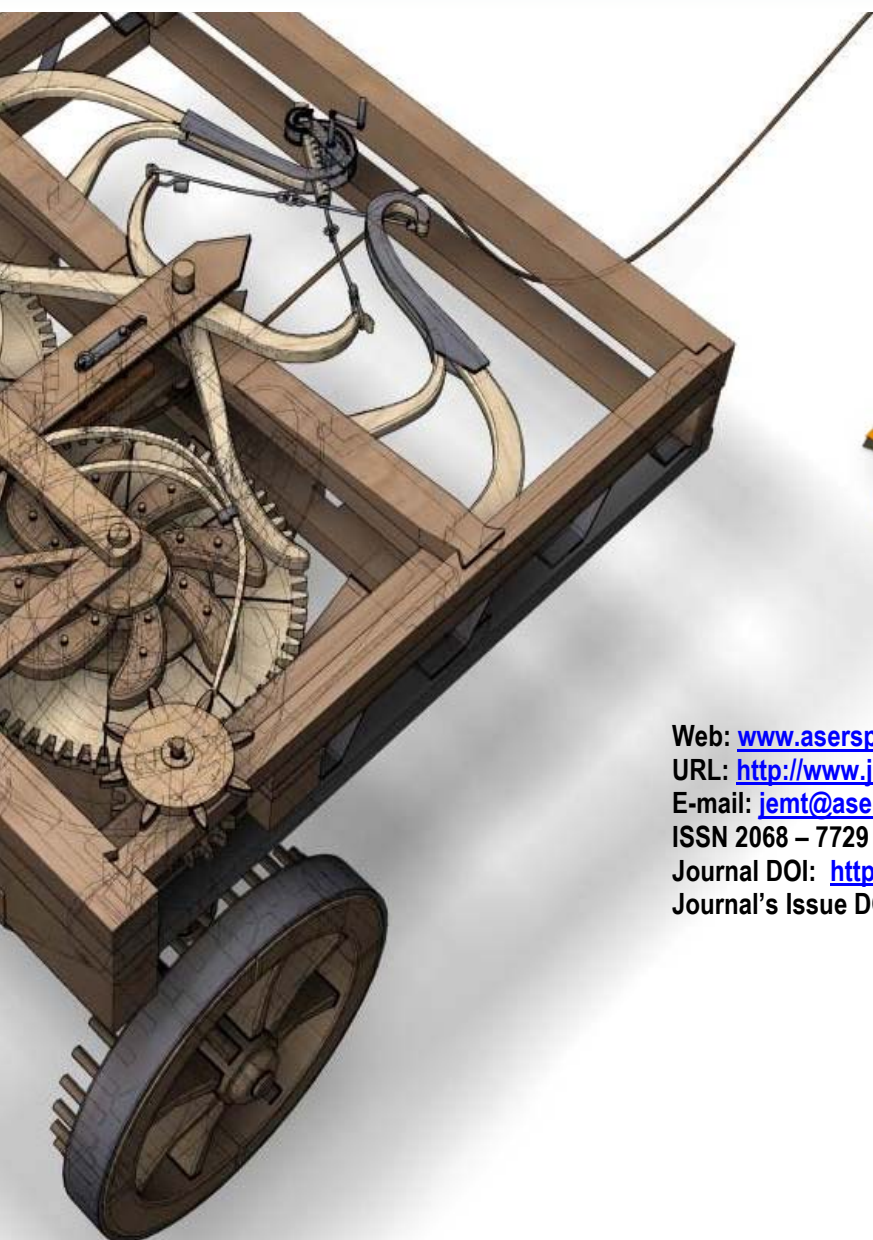
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