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Cenopopulation Status Assessment of Vegetative Cover of Coastal North-Eastern Pre-Caspian Area

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Abstract:

In oil-producing regions, oil pollution occurs, which, among other things, causes problems related to conservation of the region's biodiversity. Therefore, acquisition of knowledge about the state of the unique nature of Northern Caspian, which is under an intensified anthropogenic press, and study of the current state of marine and coastal biota, is an urgent problem for modern Kazakhstan. The territory is located in a desert zone, in the subzone of steppificated northern deserts. In the zonal terms, this is a transitional azonal band between the subzones of the mid-latitude absolute and northern steppificated deserts. Even more significantly, it is located between the contrasting ecosystems of the sea and land. Such a geographical location predetermines the heterogeneity of spatial differentiation and the dynamics of vegetation. Moisture and salinization regimes are the main

limiting factors for the botanical composition of communities. In this regard, the vegetative cover is characterized by a poor floristic and phytocenotic diversity and a simple structure. This is also due to the youth of the territory, periodic transgressions and regressions of the Caspian Sea and a constant influence of the surging sea.

As a result of intensive grazing use of the territory in the previous years, there are areas of saltwort-sagebrush degraded vegetation in the areas of increased concentration of agricultural animals, characterized by a lower vitality of *Artemisia*, its thinning and abundant growth of annual saltworts: *Ceratocarpus arenarius*, *Climacoptera brachiata, Salsola paulsenii* and *Salsola nitraria* that reduce significantly the grazing characteristics of grasslands and are indicators of anthropogenic activity.

In recent decades, the society has increasingly used information about the state of the natural environment in its activities. This information is needed in the daily life of people, in the management of the economy, in construction, in emergency circumstances – to alert people of the imminent natural calamities. However, changes in the state of the environment also occur under the influence of biospheric processes associated with human activities. To determine the contribution of anthropogenic factors to these changes is an important and difficult task.

Abundance of species and phytobiotic structure are important indicators of the state of the environment, the degree of anthropogenic disturbance and pollution. As a result of the research, data on flora, composition and structure of vegetation will be obtained.

Keywords: vegetation; flora; monitoring; Caspian Lowland; ecological conditions; vegetation community

JEL Classification: Q18; Q24; Q51; Q57.

Introduction

The formation of flora and vegetation occurs under special climatic conditions, the main of which are: increased saturation deficit; significant daily and annual variations in atmospheric temperature; cold winters and long hot summers.

The main natural factor of impact in the area under consideration is fluctuations in the level of the Caspian Sea changing the nature of soil moistening and, accordingly, causing a change in xerophytic vegetation to meadow and vice versa (Atamuradov 1994; Babaev 1994).

A distinctive feature of the vegetative cover of the Caspian Sea is its spatial heterogeneity, that is, complexity. Key factors out of those determining the spatial distribution of vegetation are moistening conditions, salinity and the mechanical composition of soil, as well as the relief. Conducting research on the current state of flora and vegetation through monitoring studies offers an opportunity to create a database that will allow further ecological monitoring of the coastal zone of the Northern Caspian (Bohn *et al.* 2000; Lisitsyna 1995).

The Pre-Caspian region is characterized by a complex nature of the vegetative cover caused by secular variations in sea levels and soil detachment and salinization processes, solifluction and the microrelief structure. Halophytization of vegetation due to surges of saline sea waters, while on land due to salinization of soils as a result of their underlayment by salinized sedimentary marine deposits and wicking of alkali soil water is observed everywhere (Kalustov 1995; Mikhailov and Fet 1994).

The variety of factors of anthropogenic impact in nature management entails a different degree of transformation of ecosystems. However, the stability or vulnerability of certain species of flora in relation to specific factors of impact and their cumulative effect varies not only in different natural zones, but also in different ecological types of ecosystems (Pereladova *et al.* 1997; Rachkovskaya 1995). The nature, speed and direction of anthropogenic changes in ecosystems and biodiversity are influenced not only by the anthropogenic factors themselves but also by their duration, load degree, initial state and degree of transformation of ecosystems and their components (soils, vegetation, etc.) in the surrounding area, ecological and biological reactions of species and many other aspects. To preserve the landscape and biological diversity of a particular area, one needs knowledge of formation conditions, natural and anthropogenic dynamics and structure of ecosystems, biological properties of flora and vegetation species. Dominants of anthropogenically disturbed ecosystems are specific – perennial *Peganum harmala* and *Dodartia*, as well as annual *Xanthium strumarium* (Starobogatov 1994; Zohary 1973).

Fluctuations in the Caspian Sea levels have been known since the prehistoric period, and they still occur today. On the coastland, in the Akzhayik reserve and the adjacent territory, the land is liberated and the areas of alkali soil and halophytes grow due to the sea regression. Part of the Karakamys natural boundary territory the route of the authors' expedition ran through is now alkali soil with thin halophytic vegetation, although in old maps, the territory is designated as the aquatic compartment of the Caspian Sea. According to stories told by local residents, water used to reach the protective dams adjacent to the city of Atyrau. Currently, the condition of tamarisk and reed thickets adjacent to the dams is depressed, and the territory is being halophytized.

In the study area, there are deposits that are currently unused as arable land. The following seral processes occur in the long-fallow areas: field weed, *Ephemeral*, annual *Salsola, Xanthium, Atriplex,* and other stages of development.

1. Literature Review

To keep track of the flora and vegetation on the sites laid out, observations were made to monitor their condition. Indicators of the processes are ecological-genetic series of phytocenoses, that is, spatial series where plant communities are located next to each other in the sequence in which they rotate in time in accordance with changes in the environment (Akiyanova *et al.* 2006; Atlas of the Kazakh SSR. Natural Conditions and Resources 1982). Thus, an ecological-genetic series represents a series of communities (or part of a series) spread in space (what is meant by a series is a sequence of communities in time caused by one succession). These series are characterized by a genetic linkage among their members. Examples of ecological-genetic series would be belts created by vegetation in drying and overgrown reservoirs or on the surface of rocks destroyed by weathering. Depending on the course of weathering and soil formation, a series of phytocenoses develops within a 'rock field', that is, a zone homogeneous in its lithological conditions, which, despite a number of differences, have a certain floral identity and gradually evolve into each other so that all the vegetation of the 'rock field' forms a consistent interconnected system. This is one of the examples of an ecological-genetic series development (Viktorov and Remezova 1988; Burlibaeva *et al.* 2007).

In vegetative cover, there is a huge number of ecological series of plant communities. Among them, there are both ecological-genetic series and those where members of a series have no genetic linkage with each other. Ecological-genetic series vary in the following two features: 1) the transition smoothness of neighboring phytocenoses; and 2) the presence of ecological relics in neighboring areas of communities. What is meant by smooth transition is some indetermination of boundaries between neighboring sections of communities and gradual ecological succession in space. However, this feature is not decisive since there are cases when sections of communities do not have genetic affinity with each other, yet, neither do they have clear boundaries. Ecological relics are a more reliable feature. These are certain species or individual sinusiae or whole microcenoses that exist as small impregnations in the background of the community that occupies a site at the present time but are remnants of the phytocenosis that existed there earlier (Grossgeim 1949; Gulenkova and Krasnikova 1976).

2. Methodology

Assessment of the status of cenopopulations was taken on monitoring sites laid out in 2015. The monitoring platform No. 1 is located on an alluvial-deltal plain on the left bank of the Zarosly canal. Geographical coordinates of the site are: N – 47 ° 00' 06,9", E – 51 ° 43' 55,4", the altitude above the sea level is -23 m. The size of the site with grass community is 1 sq.m. Grasses-*Petrosimonia-Karelinia* with motley grass community is one of the most common communities of the alluvial-deltal plain and consists of cenopopulation of *Karelinia, Petrosimonia* and grasses. Motley grass of *Kermek, Zhantak, Lepidium,* etc. mixes with them. In 2015, the projective cover degree was 80%. The community dominant, *Karelinia caspia,* prevailed. The average length of the cenopopulation with the projective coating of 30% was 30-55 cm; there were four plants. The average length of the cenopopulation of *Petrosymonia braciata,* which is the subdominant of the community with the projective cover degree of 25%, was 15-25 cm, with the number of plants amounting to 21. *Puccinellia distans* and *Leymus multicaulis* with the projective cover degree of 10% made the grasses cenopopulation, with *Elytrigia repens* sometimes mixing with them. The average length of the cenopopulation is 30-55 cm, with the total number of grasses is 27. The deterioration in the life condition of *Puccinellia distans (Puccinellia)* was observed consisting in premature desiccation and partial overgrazing. *Alhagi pseudalhagi, Limonium gmelinii and Limonium suffruticosum, Atriplex tatarica and Polygonum aviculare* were involved in establishment of motley grass.

In 2016, the projective cover degree in the community was 90-95%, while the length of the grass stand reached 60-70 cm, which was facilitated by abundant precipitation during the spring period and in the first half of summer period (Doskach 1979; Ivanov 2000). The percentage of projective cover in grasses increased by 10% and in motley grass by 5%.

The summer of 2017 was dry and sultry, the state of *Ephemerals* was observed to be critical, while more stable annual *Salsolas* were depressed.

Site No. 2 is located on the alluvial-deltal plain on the left bank of the Zarosly canal. Geographical coordinates of the site are: N – 47 ° 00' 06.8", E – 051° 43' 56.1", the size of the frutescent community site is 100 sq.m. A motley grass-grasses-*Tamaricaceae* with coarse grasses and *Artemisia* community is also widespread on the alluvial-deltal plain. The community consists of cenopopulation of *Tamarix,* motley grass and grasses mixed

with *Artemisia* and coarse grasses. In 2015, the total projective cover degree was 80%. The projective coverage of the cenopopulation of the community dominant, *Tamarix ramosissima,* was 40%, the length was 200-280 cm, the life condition was good, the number of bushes was four. The cenopopulation of grasses occupying 30% of the projective cover consists of *Puccinellia* and *Leymus*, the life condition of *Puccinellia distans* is bad, the number of grasses is 354, the average length of the grass stand is 35-50 cm. The cenopopulation of motley grass occupying 10% of the projective cover is formed by *Karelinia, Alhagi, Limonium, Atriple;* the total projective cover degree is 20%, the total number of grasses is 95, the average stand length is 30-50 cm, the life condition is good.

Anthropogenic changes in the vegetation cover are characterized by a certain presence of weed plants in the community, such as *Sophora alopecuroides, Convolvulus arvensis,* etc. (Ivanov and Sokolsky 2000; Kozybaev 1981). According to the geobotanical descriptions of 2016, an increase in the projective cover percentage by 5-10% and an increase in the length of the grass stand is mainly observed in grasses.

Sites No. 3 and 4, sized 1 sq.m. and 25 sq.m., respectively, are located 70 m to the east of an obelisk erected to perpetuate the memory of Bolsheviks shot at the shore of the Ural River. The sites with juvenile specimens of *Tamarix* on meadow alluvial alkaline soils among reed thickets were laid out and described in 2015. Geographical coordinates are: N – 46 ° 54'35.6", E – 051 ° 40' 59.5". Cenopopulation of *Tamarix* with the total projective cover degree of 40-50% consisted of *Tamarix* undergrowth. On 1 sq.m., there were 48 specimens, 350 specimens were placed on 25 sq.m., the average length of plants was 15-18 cm, the condition of plants being good. The soil surface of was cracked; in places, littering with metal products (pipes, spare machinery parts) was observed. Single specimens of *Bolboschoenus, Aeluropus, Solanum,* and others were encountered.

Site No. 5, its size being 1 sq.m., comprises *Petrosimonia-Suaeda* community. Geographical coordinates are: N – 46 ° 54' 24.7", E – 051 ° 39' 24.7", the total projective cover degree is 20%. In addition to the cenopopulation of *Petrosimonia* and *Suaeda*, other microgroups of *Salsolas* are mixed with sparse vegetation. The length of the *Suaeda* microgroups dominant with the projective cover of 15% reaches 20-25 cm, the one of *Petrosimonia* with the projective cover of 5% reaches 15-18 cm.

Site No. 6, the size of the site being 100 sq.m., comprises annual *Salsola-Aeluropus*-frutescent with *Atriplex* and *Artemisia* community with the total projective cover degree of 70%. Geographical coordinates:

1) N – 46° 56' 03.8", E 051° 50' 55.6"
2) N – 46° 56' 03.9", E – 051° 50' 55.1"
3) N – 46° 56' 04.2", E – 051° 50' 55.4"
4) N – 46° 56' 04.1", E – 051° 50' 55.8"

The projective cover degree of the cenopopulation of halophytic shrubs is composed of *Tamarix, Halostachys and Kalidium.* The height of *Tamarix* bushes is 50-70 cm, the projective cover degree is 30%, the height of *Halostachys* bushes is 100-120 cm, the projective cover degree is 15%, the height of *Kalidium* bushes is 80-100 cm, and the projective cover degree is 5%. The cenopopulation of *Aeluropus littoralis,* with the height of 10-15 cm, occupies 15% of the projective cover. Cenopopulations of annual *Salsolas: Climacoptera, Suaeda and Petrosimonia,* occupy 10% of the projective cover.

Artemisia nitrosa, Atriplex tatarica and *Lepidium* are also involved to some extent in the composition of the grass stand of the frutescent community. The condition of halophytic shrubs (*Halostachys* and *Kalidium*) and annual *Salsolas* (*Petrosymonia, Climacoptera*) is excellent, while grasses, on the contrary, are depressed. Apparently, intensive salinization of soil occurs, and the groundwater occurrence depth increases (Gunin and Vostokova 1989).

The parameters of any plant community do not remain unchanged but fluctuate from year to year. Their values in different years turn out to be larger or smaller relative to the average value for a certain but not too long period, that is, they oscillate about the average characteristic. The time of passing phenological phases, the abundance of species and their ratio, the phytomass vary, and changes the floristic composition may also occur (Magurran 1988; Rachkovskaya *et al.* 1999). The reason that determines these changes is fluctuations in weather conditions – the amount of solar energy intake by plants, the temperature condition, and the amount of precipitation. The dynamic existence conditions provide advantages to one or another species, which leads to a change in the system of interactions between plants. Such vibrational changes in plant communities have been called fluctuations.

3. Results

Surging periodically repeating on the sea coast constitutes a particular threat to the biodiversity of the delta of the Ural River. In this case, their consequences can be most diverse – from deterioration of navigation circumstances to dam failures, building destruction and coastal encroachment up to 10 km.

The floral and phytocenotic diversity of the project area is poor, which is also due to periodic transgressions and regressions of the sea. A distinctive feature of the floristic spectrum of the territory is the dominant position of representatives of the *Chenopodioideae* family (about 20% of the total number of species) and a high position of the *Potamogetonaceae* family (3%).

It is well known that each element of flora plays its own role in vegetative cover. Some species, due to their small size, short vegetation period and insignificant abundance, are practically invisible and have little effect on the vital activity of ecosystems, while mass species are dominants and subdominants of plant communities. They produce bulk of organic substances, etc.

The main common species of the territory under study is *Phragmites* that produces heavy bed occupying huge areas of shallow and coastal waters. *Phragmites* creates green aspect during the whole vegetation period (Serebryakov 1962; Sydykov *et al.* 1995).

In the first half of 2015, in Kazakhstan, including in the Atyrau region, a record amount of precipitation occurred that contributed to good development of desert vegetation and vegetation of the alluvial-deltal plain.

Monitoring platform No.1 with grasses-*Petrosimonia-Karelinia* with motley grass community is laid out in a few dozen meters from the fish canal. The community is polycomponent. In 2015, the total projected cover degree was 80%; the average length of the grass stand was 30-50 cm. There was deterioration in the life condition of *Puccinellia distans* expressed in premature desiccation and partial overgrazing. In 2016, the projective cover degree in the community was 90-95%, the length of the grass stand reached 60-70 cm, which was facilitated by abundant precipitation in spring and in the first half of the summer period. The percentage of grasses in the projective cover increased by 10% and of motley grass by 5%.

While in 2015 *Karelinia caspia,* with the projective cover degree of 30%, took the dominant position, and *Petrosimonia* took the subdominant position, in 2016 the overall projective cover increased. If the degree of *Karelinia* and *Petrosimonia* involvement increased by 5%, the one of grasses increased by 10% resulting in grasses becoming subdominants of the community. Due to scanty rainfall and the influence of the hot summer of 2017, there was vegetation damage (Table 1).

Table 1. Grasses-*Petrosymonian-Karelinian* with motley grass community

Species	2015			2016			2017		
	% of involvement	length, cm	number of individuals	% of involvement	length, cm	number of individuals	% of involvement	length, cm	number of individuals
Karelinia	30	30-55	4	35	40-55	6	25	25-30	3
Petrosimonia	25	15-25	21	30	20-30	25	20	10-15	15
Grasses	20	30-55	27	30	50-70	43	5	25-30	15

Site No.2 is laid out on the alluvial-deltal plain near the left bank of the Zarosly canal. The size of the shrub community site is 100 sq.m. The motley grass-grasses-*Tamarix* with coarse grasses and *Artemisia* community is also widespread on the alluvial-deltal plain. The community consists of cenopopulation of *Tamarix*, motley grass and grasses mixed with *Artemisia* and coarse grasses (Table 2).

The total projective cover degree in 2015 was 80%, of which 40% belonged to *Tamarix* whose height ranged within 100-160 cm. Grasses, 30-55 cm high, represented by *Puccinellia* and *Leymus*, accounted for 30% of the projective coverage.

Grasses, their height varying from 15 to 80 cm, are represented by *Limonium, Alhagi and Karelinia,* the projective cover degree is 10%. Anthropogenic changes in the vegetation cover are characterized by the presence of weed plants in the community, such as *Sophora alopecuroides, Convolvulus arvensis* and *Artemisia*.

Table 2. Motley grass-grasses-*Tamarix* with coarse grasses and *Artemisia* community

Species	2015			2016			2017		
	% of involvement	length, cm	number of individuals	% of involvement	length, cm	number of individuals	% of involvement	length, cm	number of individuals
Tamarix	40	100-160	4	40	100-160	6	40	100-160	6
Puccinellia	15	30-35	200	15	40-45	230	10	20-25	165
Leymus	15	45-55	154	25	50-80	200	5	30	103
Alhagi	3	10-25	60	3	20-30	70	3	10-25	60
Karelinia	2	80-90	14	2	60-75	17	2	60-70	10
Limonium	3	10-25	21	3	10-25	25	2	10-12	15
Styphnolobium	1	10-15	7	1	10-15	7	1	10-15	7
Convolvulus	1	20-50	3	1	20-50	3	1	15-20	3

4. Discussion

According to the geobotanical descriptions of 2016, an increase in the projective cover percentage by 10% and an increase in the length of grass stand is observed mainly in grasses. In 2017, general vegetation damage was observed.

Sites No. 3 and 4, 1 sq.m. and 25 sq.m. in size, respectively, with juvenile specimens of *Tamarix* on meadow alluvial alkaline soils are laid out among reed thickets. The cenopopulation of *Tamarix* with the total projective coverage of 40-50% consisted of *Tamarix* undergrowth in good condition. The soil surface was cracked; in places, littering with metal products (pipes, spare machinery parts) was observed. Few specimens of *Bolboschoenush, Aeluropus, Solanum,* and others were encountered.

Due to heavy precipitation, the site was flooded before the end of July 2016; by mid-August 2016, it dried up (Whittaker 1960). The territory overgrown with juvenile *Tamarix* specimens altered completely, the height of *Tamarix* individuals reached 30-70 cm; the *Phragmites* cenopopulation 100-150 m high, with the projective cover degree of 30%, predominated in the grass stand of the community; *Bolboschoenus,* 20-30 cm high, became subdominant. Thus, among reed thickets, *Tamarix-Bolboschoenus-Phragmites* community grew with the projective cover degree of 65-70%. In 2017, the sites 3 and 4 were completely overgrown with reeds.

Site No. 5, with the *Petrosimonia-Suaeda* community in 2011, consisted of sparse cenopopulations of *Petrosymonia* and *Suaeda*, in places mixed with individual specimens of other annual *Salsolas*. In 2016, other species such as *Chenopodium album, Climacopteras lanata* and *crassa*, etc. increased their share in the vegetation structure (Table 3). The total projective cover increased to reach 30%, in places 40%. In this community in 2016, the number of species, the total projective coverage and the length of the grass stand increased. In 2017, the community structure and the degree of their involvement did not change, but general deterioration in the condition of plants was observed.

The vegetation of site No. 6 is represented by annual *Salsola-Aeluropus*-shrub with *Atriplex* and *Artemisia* community dominated by cenopopulations of halophytic shrubs – *Tamarix*, *Halostachys* and *Kalidium* (Table 4).

In 2015, the height of the shrub layer was 70-120 cm, the *Tamarix* condition was moderate, while the other shrubs were in good condition. The condition of the *Aeluropus littoralis* cenopopulation was depressed, premature drying of *Aeluropus* was observed. The life condition of annual *Salsolas* constituting 10% of the projective coverage was good.

The condition of *Artemisia nitrosa* and *Atriplex tatarica* insignificantly involved in the structure of the community grass stand was moderate.

Table 3. *Petrosymonia-Suaeda* community

Species	2015		2016			
	length, cm	number of individuals	length, cm	number of individuals	length, cm	number of individuals
Suaeda	15	20-25	35	20	25-30	42
Petrosimonia	5	15-18	12	10	20-25	15
Chenopodium	-	-	-	2	30	4

Species	2015			2016		
	length, cm	number of individuals	length, cm	number of individuals	length, cm	number of individuals
Climacoptera lanata	-	-	-	3	10-15	5
Climacoptera crassa	-	-	-	2	10-15	5
Eremopyrum	-	-	-	3	10-15	7

In 2016, the projective coverage and condition of halophytic shrubs remained unchanged, the halophytic grass *Aeluropus littoralis* and annual *Salsolas* developed excellently, their projective coverage being 25% and 18%, respectively. The degree of *Artemisia* and *Atriplex* involvement also increased. In 2017, the condition of plants was depressed.

Table 4. Annual *Salsola-Aeluropus*-shrub with *Atriplex* and *Artemisia* community

Species	2015			2016		
	length, cm	number of individuals	length, cm	number of individuals	length, cm	number of individuals
Tamarix	30	50-70	14	30	50-70	14
Halostachys	15	100-120	7	15	100-120	7
Kalidium	5	80-100	5	5	80-100	5
Aeluropus	15	10-15	25	25	3	37
Climacoptera crassa	4	10-15	22	10	10-15	25
Suaeda	3	15-20	17	3	15-20	21
Petrosimonia	3	10-15	18	5	10-15	8
Artemisia	<1	20-30	3	1	25-35	14
Atriplex	<1	20-30	3	1	20-40	12

Conclusion

Thus, in the context of observations over three years, the following fluctuation changes occurred: due to the favorable climatic conditions of 2016 for plants of the Ural river delta, there has been a good development of grasses, such as *Aeluropus, Leymus, Puccinellia, Elytrigia* and annual *Salsolas* represented by the species of *Climacoptera, Petrosimonia and Suaeda.* The degree of their involvement in the projective cover has grown and the length of the grass stand has increased. In 2017, due to unfavorable climatic conditions of the year, the general condition of plants in the study area was depressed.

Conducting research on the current state of flora and vegetation through monitoring studies makes it possible to create a database that will allow for further environmental monitoring of the coastal zone of the Northern Caspian.

As a result of the studies, the following results have been obtained: the dominant position of the *Chenopodiaceae* family (about 20% of the total number of species) and a high position of the *Potamogetonaceae* family (the 7th place, 3%) are distinguishing features of the floristic spectrum. This indicates a significant salinity of land habitats and an increased role of aquatic phytocenoses. Perennial *Peganum harmala* and *Dodartia,* as well as an annual *Xanthium,* are specific dominants of anthropogenically disturbed ecosystems. On all the monitoring sites, plant population grows in the conditions of a close occurrence and salinization of groundwater. It has been revealed that the highest alpha diversity among the described species belongs to grasses-motley grass with coarse grasses communities, where the species abundance of the communities amounts to 41 species, while the species saturation of the described areas does not exceed 21 species. Assessment of beta diversity has been carried out through calculation of the heterogeneity index. The highest index level 1.8 is found in motley grass-grasses with shrub vegetation and coarse grasses community, and the lowest, 0.9, is in grasses-motley grass with coarse grasses community.

When studying the dynamics of flora and vegetation, fluctuation changes in vegetation were identified taking into account the time of passing phenological phases, the abundance of species and their ratio, phytomass and floristic composition. The reason for these changes is fluctuations in weather conditions – the amount of solar energy intake by plants, the temperature condition, and the amount of precipitation.

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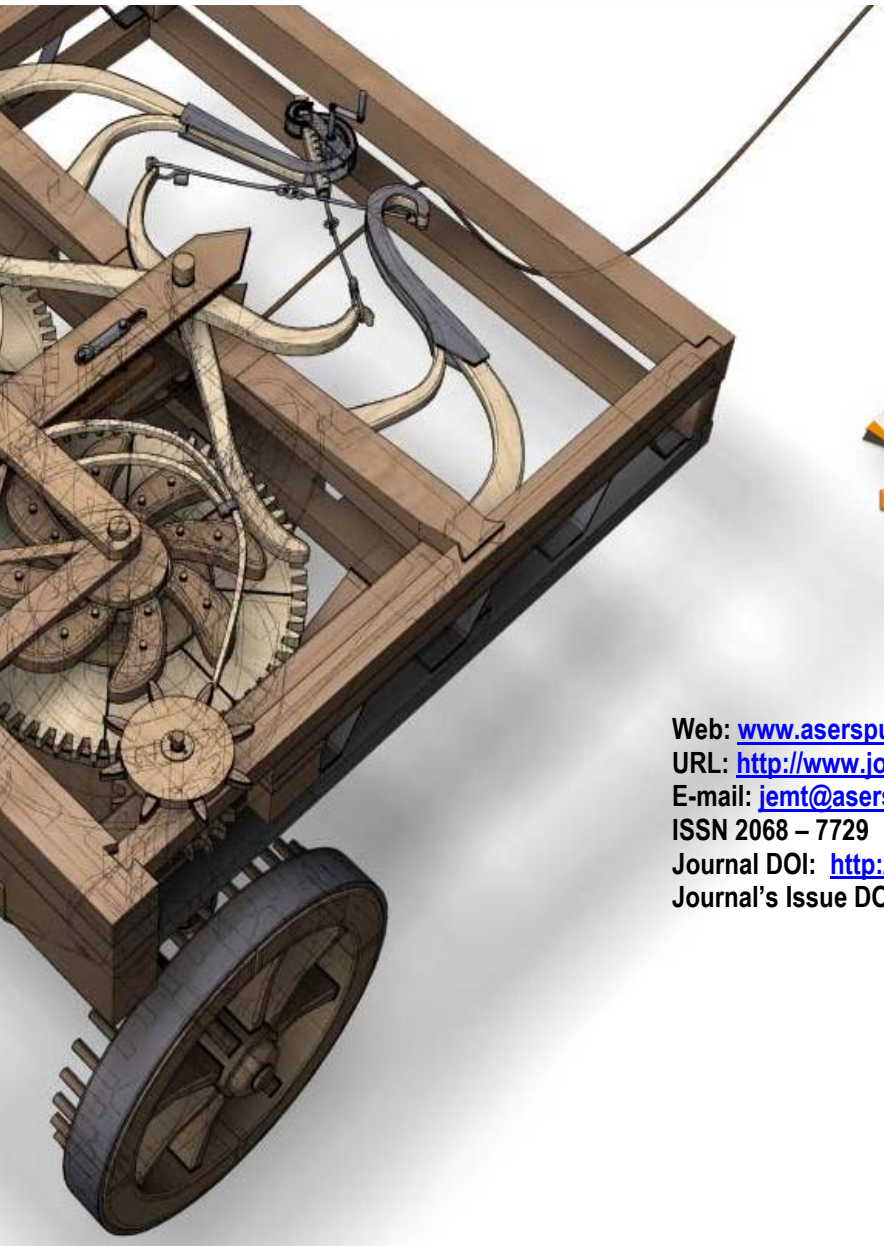

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