

Geocological analysis of recreational load on the beaches of the Kalamitsky Gulf of Crimea

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Abstract. The beaches of the Kalamitsky Gulf are experiencing high anthropogenic load, over past decades the area of many beaches has significantly decreased, their recreational value has fallen. The purpose of this work is to conduct a geocological analysis of recreational load on the beaches of the Kalamitsky Gulf of Crimea. To achieve this goal, the recreational load on the beaches of the Kalamitsky Gulf of Crimea was calculated using remote observation methods with the use of geographic information systems and video surveillance cameras in real time. It was found that at the moment the recreational load is within the norm, which is due to the closed air traffic and less intense tourist flow for 2022-2024.

1 Introduction

The most common type of beach use is recreation and tourism. This area is characterized by pronounced seasonal unevenness, which leads to large peak loads in summer. This has a negative impact on ecological state of both beaches and coastal-aquatic complexes as a whole [1].

The study of this issue began in the 1970s in both foreign and domestic sources. Over more than fifty years of research various natural communities have been considered, and appropriate methods for calculating the negative impact have been developed.

Recreational load is an integrated indicator of recreational impact, determined by the number of vacationers per unit area, the time of their stay at the recreational facility and the type of recreation.

Consequences of large recreational load include littering the beach, trampling the vegetation in adjacent areas, and development of unauthorized recreational facilities [2]. This is especially evident in unorganized recreation.

Recreational sustainability is the ability of any ecosystem to withstand recreational loads while maintaining all its properties and components and having the ability to self-recovery. There are various sets of measures to increase recreational sustainability, in case of beaches these are coastal protection structures (namely, their correct selection and use), sowing perennial grasses on cliffs, etc. [3].

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According to the degree of impact, recreational loads can be divided into three types:

1. Critical - when this load is reached within the ecosystem irreversible changes occur that contribute to its destruction;
2. Permissible - maximum permissible recreational load that does not lead to irreversible changes;
3. Inadmissible - load above the critical.

These indicators are determined by the territory ecological capacity - the level of recreational load that any ecosystem can withstand without irreversible disruptions in functioning, i.e. maximum number of people, who can be in any territory without harm to it [4].

To determine these indicators, it is necessary to take into account two tasks - measuring the level of accumulated damage to the ecosystem, as well as standardizing the recreational load depending on the state of specific ecosystem and external factors affecting recreational sustainability [5].

It should be understood that beaches and coastal-aquatic ecosystems are rather complex object for calculating the recreational load due to noticeable differences with forest/steppe ecosystems (almost complete absence of vegetation, soil, unique conditions of landscape formation, etc.).

2 Materials and Methods

The study object are the beaches of the Kalamitsky Bay (Figure 1), located on the territory of the Crimean Peninsula. The bay extends 13 km into the peninsula, and its total length from north to south reaches 41 km.



Fig.1. Kalamitsky Bay beaches for 2021 (top) and 2024 (bottom)

Among water bodies it is worth highlighting the numerous estuary-type salt lakes (for example, Sasyk, Sakscoye, Kyzyl-Yar and Bogayly) , as well as the Western Bulganak and Alma rivers.

Vegetation is rather poor due to insufficient moisture, saline soils and the sea proximity. Among the typical representatives, we can highlight the flax-leaved flat-fruited grass

(*Meniocus linifolius*), eight-leaved bedstraw (*Galium octonarium*), erucifolia-leaved sicklewort (*Serratula erucifolia*), Ukrainian milk vetch (*Astragalus ucrainicus*), dirty nagolovatka (*Jurinea sordida*), Russian nonea (*Nonea rossica*), simple iberic grass (*Iberis simplex*), Crimean goat's-foot (*Scorzonera taurica*), barley brome (*Bromus hordeaceus*), and Kum broomrape (*Orobanche cumana*) [6].

On the western coast of the Crimean peninsula, the number of days with water temperature of +16 °C and above is 150.

Three areas with relatively developed recreational activities were selected for the measurement (Figure 2).

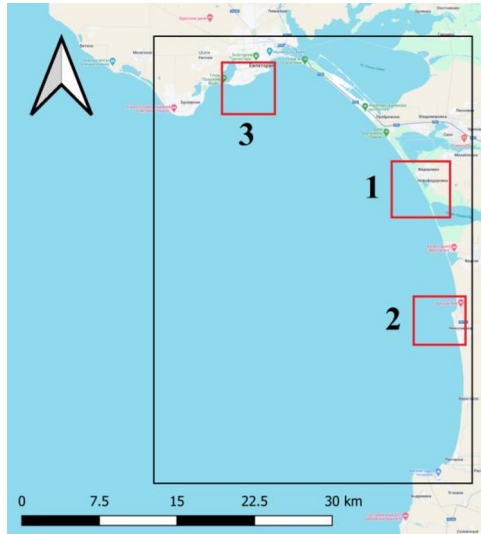


Fig. 2. Location of research areas

The area and length of the beaches were calculated using QGIS software.

Such indicators as the number of urns, compliance with sanitary and hygienic standards (number and distribution of toilets and showers), granulometric composition of the beaches, etc. were recorded to calculate the correction factors.

Next, based on the data obtained, the average number of visitors was calculated using the detailed method of accounting in places of mass recreation. This indicator is calculated using the following formula (1):

$$P_{av} = \frac{3,3 * M * K}{S}, \quad (1)$$

where P_{av} - average number of visitors per 1 ha, people;

M – number of visitors to the object, recorded during two-hour observations, people;

K – coefficient of shift work of visitors to the object (for beaches it is considered equal to 2);

S – object area being accounted for, ha.

According to GOST R 58737-2019 the standard area per vacationer should be at least 5 m² for sea beach. There are also standards for minimum length of coastline per visitor. This indicator depends on the type of beach (0.28 m for sandy beaches, 0.26 m for sandy and pebble beaches and 0.25 m for pebble beaches). These values can be expressed as the maximum number of people per linear meter of beach - 3.57; 3.85 and 4 people/l. m, respectively.

According to the methodology of the All-Union Scientific Center for Medical Rehabilitation, [4] it is possible to calculate the maximum permissible one-time recreational load. This indicator is calculated using the following formula (2):

$$E_m = K_1 * K_2 * n * l, \quad (2)$$

where E_m – maximum permissible recreational load (persons),

K_1 – socio-ecological coefficient (varies from 0.5 to 0.8 depending on the degree of negative impact of anthropogenic activity on natural complexes near study sites),

K_2 – coefficient of recreational attractiveness (varies from 0.4 to 0.8 depending on beach improvement degree, popularity of recreation area, as well as its proximity and transport accessibility in relation to administrative centers),

n – standard for the maximum permissible load (persons/l. m),

l – beach length.

During field observations, it was decided to consider K_1 equal to 0.6 for beaches No. 1 and No. 3 due to the roads, laid nearby, presence of capital structures and water supply system; for beach No. 2 the value of 0.7 was chosen - since in addition to the above factors, there are the regulated coast (presence of breakwater walls, concreted areas of the beach), which led to significant change in the beach.

Coefficient K_2 for beach No.1 and beach No. 2 was equal to 0.6, since this is a fairly popular vacation spot for residents of nearby villages and towns, which is explained by transport accessibility and close location. For beach No. 3 this coefficient was equal to 0.7 - the city near it, has greater recreational specialization, more developed infrastructure, which annually attracts the largest number of tourists to the western coast of Crimea.

Also, for each beach, such indicator as beach and swimming resource, i.e. the maximum "throughput" of particular beach in one tourist season is calculating. This indicator depends on factors such as climatic conditions, beach area, as well as its recreational capacity (maximum permissible recreational load) and is calculated using the following formula (3):

$$P = R * S * T, \quad (3)$$

where R – recreational capacity of the beach, people/ha;

S – beach area, ha;

T – number of days per year with comfortable conditions for swimming (water temperature +16 °C and above).

3 Results and discussion

Based on the data obtained, the average number of vacationers on the beach on weekdays and weekends was calculated (Table 1).

Table 1. Characteristics of the relevant areas

Indicator \ Beach	№1	№2	№3
	2	3	4
Area, ha	0,27	0,08	0,23
Beach length, m	36	41	59
Type of beach	sand-pebble	pebble	sand
M10 (weekdays), persons	26	12	27
M10 (weekends), persons	33	20	27

Continuation of Table 1

1	2	3	4
M12 (weekdays), persons	14	12	33
M12 (weekends), persons	26	21	44
M18 (weekdays), persons	20	11	27
M18 (weekends), persons	35	22	28

The results of the conducted studies showed that the recreational load on the beaches of Kalamitsky Bay in the summer of 2023 is significantly less than the calculated standard. The calculation results are presented in Table 2.

Table 2. Estimated average number of visitors using a detailed accounting method in places of public recreation on the studied sections of the beach

	No. 1	No. 2	No. 3
P_{av} (weekdays)	684	2145	2353
P_{av} (weekends)	1613	4372	2525

The results obtained differ due to various factors: popularity of the resort, density of tourist accommodation, presence of stationary recreation centers nearby, etc. The level of equipment of each of them can be classified as average, since there is a basic infrastructure of city beach - trash bins, public toilets, sun loungers, equipped slopes.

The obtained results were compared with previously published studies regarding other beaches of the southwestern coast of Crimea. These beaches are not part of the Kalamitsky Gulf, but are in similar conditions and have a similar structure, in addition, they have published data on recreational load, which makes it possible to compare the results of personal observations and draw appropriate conclusions.

Unfortunately, the calculated indicator takes into account only the beach length, but not the width, which leads to increased values in narrow sections of the coast. Because of this, the maximum permissible recreational load is not always appropriate to use for comparing the resistance of beaches to anthropogenic load. This is especially evident on the southwestern coast of Crimea, since the beaches width here can vary from several to hundreds of meters or more.

Based on the data obtained, the beach and bathing resource was calculated for the above research areas (Table 3).

Table 3. Values of maximum permissible recreational load on the beaches of the southwestern coast of Crimea

Beach location	Maximum permissible recreational load		Beach and bathing resource
	Persons	Persons/ha	Persons/days
No. 1	49	181	7331
No. 2	69	862	10344
No. 3	88	383	13214
Vasileva gully	297	618	20738
Uchkuyevka	168	420	25200
Konstantinovsky	21	300	315
TPP	9	150	135
Solnechny	87	580	13050
Pesochny	54	338	7960
Omega	147	735	22050
Zolotoy	108	2160	15552

Daily and weekly unevenness is of great importance, since peak loads on beaches occur during the daytime, while at night there is almost no impact. Therefore, to compare different beaches, it is necessary to consider the same time intervals. Also, the difference between weekdays and weekends (or holidays) is clearly visible; weather conditions have a great influence, for example, on third and fourth days of measurements there were unfavorable weather conditions in the form of precipitation, which significantly affected the number of tourists on the beaches (Fig. 3).

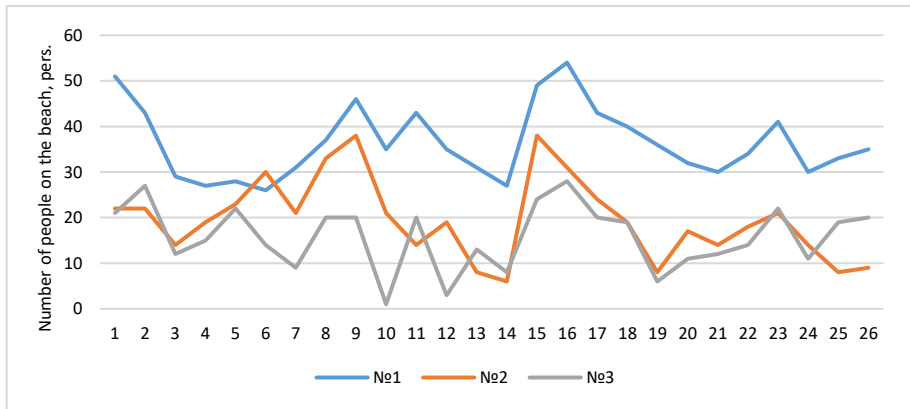


Fig. 3 Dynamics of the number of visitors to the beaches of Kalamitsky Bay at 12:00 during the month [7]

This graph shows local maximums every five days, which corresponds to the alternation of weekends and weekdays. Over the entire measurement period (including morning and evening measurements), the number of vacationers did not exceed the calculated permissible recreational load. However, it is worth considering that there has been no air traffic in Crimea for two years, which negatively affects the tourist flow, for example, the number of vacationers in 2023 was only 55% of 2021.

4 Conclusions

Clear patterns can be identified in the distribution of the number of tourists during the day and month. The largest number of recreationists on the beaches is noted on weekends in good weather, which is clearly visible in the calculation results.

In conclusion, it can be said that in the studied areas, the recreational load during the measurement period was within the permissible limits. But it is worth understanding that the average long-term load is significantly higher than the load in 2022 and 2023, and a larger data sample is needed for more accurate indicators. It is necessary to make permanent monitoring in these areas, track the dynamics and build a forecast regarding the variability of coastal ecosystems.

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