UDC 635.56
IRSTI 34.35.01
DOI 10.37238/2960-1371.2960-138X.2024.94(2).55

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GARDEN CRESS (*LEPIDIUM SATIVUM* L.) AS A BIOINDICATOR FOR ASSESSING AIR POLLUTION

Annotation. This study explores the significance of bioindication in assessing environmental quality, emphasizing the utility of garden cress (Lepidium sativum) as a bioindicator for determining air pollution levels. Bioindication offers a simple and rapid method for evaluating environmental conditions using living organisms, eliminating the need for specialized equipment. Garden cress, known for its sensitivity to soil contamination and air pollutants, demonstrates rapid seed germination and noticeable morphological changes when exposed to pollutants. The research methodology involves biotesting, snow sampling, and germination testing to assess environmental pollutants and their impact on plant growth. Results indicate varying pollution levels across different sampling locations, with pollutants increasing snow acidity and affecting seed germination rates. The study underscores the effectiveness of Lepidium sativum as a bioindicator, highlighting its rapid growth and sensitivity to environmental shifts. Ultimately, this research contributes to understanding the impact of pollutants on plant ecosystems and emphasizes the importance of environmental protection and conservation efforts.

Key words: Garden cress (Lepidium sativum); bioindicator; samples; air pollution; test object.

Introduction

The significance of bioindication lies in its simplicity and speed in assessing environmental quality. Bioindication allows for evaluating the state of the environment using living organisms, eliminating the need for specialized and expensive equipment, devices, and reagents. Certain living organisms exhibit high sensitivity to environmental changes, enabling the assessment of natural processes and anthropogenic impacts on habitats based on their abundance or developmental characteristics [1, 2].

This paper proposes the use of garden cress (*Lepidium sativum* L.) as an indicator to determine air quality [3]. Garden cress is an annual herbaceous plant belonging to the Brassicaceae family. It is native to Western Europe, Central and Western Asia, and the southern and western regions of Kazakhstan. Garden cress demonstrates heightened sensitivity to soil contamination by heavy metals and air pollution caused by vehicular emissions [4-5].

This bioindicator species is characterized by rapid seed germination, with almost one hundred percent germination rate under normal conditions, which significantly decreases in the presence of pollutants. Furthermore, both the shoots and roots of garden cress exhibit noticeable morphological changes when exposed to pollutants, such as stunted and curved shoots, reduced root length and weight, as well as decreased seed quantity and weight.

Garden cress serves as a convenient bioindicator due to its ability to study the effects of stressors simultaneously on numerous plants within a small experimental area (e.g., Petri dish, cuvette, tray, etc.). Its short experimental period is also advantageous, with seeds typically germinating within the third or fourth day, and most experimental inquiries can be addressed within a span of 10 days [5, 6].

Research Materials and Methods

The study of snow samples was conducted using the biotesting method, which entails evaluating environmental quality through the response of living organisms. *Lepidium sativum* was selected as the indicator organism due to its rapid seed germination. Seed germination and seedling growth rates were utilized as key indicators, allowing for a comparative assessment of growth and development and thereby evaluating snow toxicity levels [6].

Purpose: To explore the utility of *Lepidium sativum* as a test organism for assessing atmospheric air pollution in environmental and biological research.

Materials and Equipment: Garden cress (*Lepidium sativum* L.), snow shovel, 1-liter measuring cup (400ml), tape measure, analytical scales, flat-bottomed flasks, funnels, filter paper, porcelain dishes, meteoscope, indicators, soil, sterile beaker, Petri dish [6].

The experiment was conducted from February 2, 2024, to February 9, 2024, at four locations within our city. These locations included Victory Square, Pushkin Square, an area near Pugachev's road, and the vicinity of the Faculty of Natural Geography. A meteoscope device was employed to measure various environmental parameters, including ambient air temperature (Тв), humidity (RH), air velocity (V), and atmospheric pressure (P), at these sites (see Table 1).

Table 1 – The results of the meteoscope parameters

Location	Тв (°C) (temperature)	RH (%) (humidity)	V (m/s) (air velocity)	P (kPa) (atmospheric pressure)
Victory Square	10.18	42.2	0.32	99.85
Pushkin Square	3.63	64.8	0.39	99.84
near Pugachev's Road	6.06	53.9	0.22	99.85
The vicinity of the Faculty of Natural Geography	5.57	55.4	0.41	99.83

Snow samples are typically obtained from both the polluted surface layer and the full depth of the snow column. The depth of the snow cover varied across different locations: 27 cm at Victory Square, 30 cm at Pushkin Square, 25 cm near Pugachev's Road, and 22 cm at the area of the Faculty of Natural Geography.

For snow collection, laboratory glasses were utilized. These glasses were lowered vertically from above onto the snow surface within a designated 1x1 m² area. Each sample was carefully numbered according to the sampling site and annotated with the names of the experimenters.

Following sampling, the snow was melted using an electric stove. The level of dustiness in the territory was assessed after the snow had melted, by filtering it through filter paper (Figure 1).


a b

***Figure 1** – a) Snowmelt process; b) Filtering process*

The volume of melted snow from each sample was quantified, and the paper filters were left at room temperature until the subsequent day. Upon drying, the filters were weighed using analytical scales to determine the quantities of filter paper and dust collected. Additionally, while working with snow samples, measurements were taken of the mass of the glass, snow cover, glass height, and glass volume (Figure 2). These measurements were recorded in Table 2.

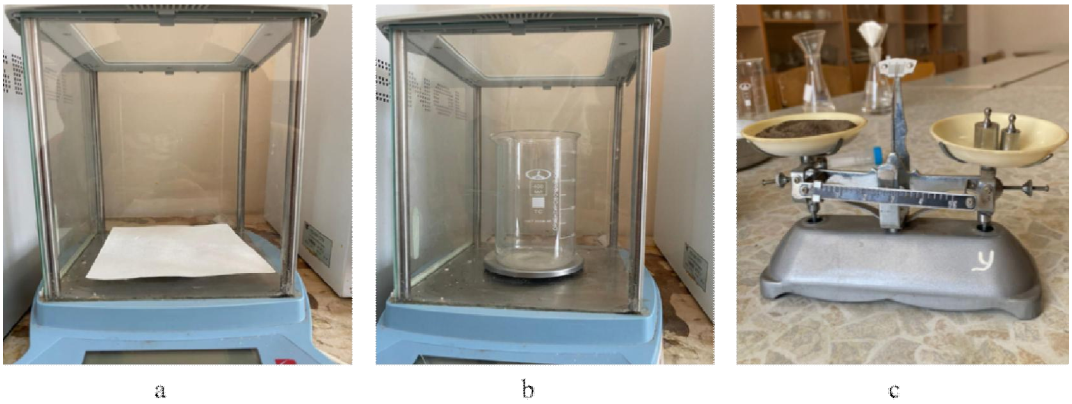
a b c

***Figure 2** - a) Measuring the mass of the filter paper;*
b) Measuring the mass of the glass;

c) Measuring the mass of the soil

Table 2 – Measurement results

	Victory Square		Pushkin Square		Near Pugachev's road		The vicinity of the Faculty of Natural Geography	
	I	II	I	II	I	II	I	II
Glass weight	137,1	151	153,2	156,5	154,6	151,7	134,1	156,5
Glass weight+snow	237	259	255,5	257,4	257	256,5	212,3	257
The mass of snow	99,9	108	102,3	100,9	102,4	104,8	55,8	122,9
Diameter of the glass	7,6	7,6	7,6	7,6	7,6	7,6	7,6	7,6
Height of the glass	13,4	13,2	13,3	13,6	13,3	13,6	13,4	13,4
V glass	607,6	598,5	603,1	616,6	603,1	616,6	607,6	607,6
Snow cover density	0,164	0,181	0,169	0,164	0,169	0,171	0,09	0,202
The weight of the filter paper	1,38	1,41	1,38	1,48	1,39	1,48	1,38	1,48
The weight of the filter paper+dust	1,45	1,45	1,43	1,51	1,45	1,49	1,44	1,49

A paper indicator is employed to ascertain the acidity of melted snow, with precipitation categorized as follows:

· Strongly acidic (pH 3-4)
· Acidic (pH 4-5)
· Slightly acidic (pH 5-6)
· Neutral (pH 6-7)
· Slightly alkaline (pH 7-8)
· Alkaline (pH 8-9)
· Strongly alkaline (pH 9-10)

Snow can exhibit both acidic and alkaline reactions, contingent upon the prevalence of specific pollutants. The findings of the study indicated that all samples contained pollutants that altered the environment to become acidic. Sulfur and nitrogen oxides present in fuel combustion byproducts are known to reduce the pH of snow, thus increasing its acidity. The study results are presented in Table 3.

Table 3 – Determination of the Acidity of Snow

The location	pH	Acidity of the medium	Color
Victory Square	4,5	acidic	yellow
Pushkin Square	5,5	slightly acidic	yellow
Near Pugachev's road	6	slightly acidic	lime green
The vicinity of the Faculty of Natural Geography	4	strongly acidic	beige

The seeds of *Lepidium sativum* designated for experimentation undergo germination testing. To conduct this assessment, the seeds are germinated in two Petri dishes. One dish is filled with washed river sand to a depth of 1 cm, while the other dish contains an equivalent volume of pure substrate, serving as a control in comparison to the test material of filter paper. Prior to seed placement, both the sand and the filter paper are moistened until fully saturated with water. Each Petri dish is then seeded with 50 *Lepidium sativum* seeds (Figure 3).

Figure 3 *- The Process of Planting Lepidium sativum*

The spacing between adjacent seeds should be as consistent as feasible. The seeds are loosely covered with glass from above. Germination occurs in a laboratory environment at a controlled temperature of 20-25°C. Seed germination progress is observed over a period of 5-7 days while ensuring the moisture levels of the substrates are sustained. Attaining a germination rate of 90-95% within 3-4 days is deemed standard practice, as depicted in Figure 4.

Figure 4 – Observations of the germination of *Lepidium sativum*

Based on the experimental outcomes, substrates are categorized into four pollution levels:

1. **No Pollution:** Seed germination ranges between 90-100%, resulting in robust and smooth seedlings. These characteristics serve as the baseline for comparison with the experimental prototypes.
2. **Low Pollution:** Germination rates fall between 60-90%, with seedlings exhibiting nearly normal length and robustness.
3. **Moderate Pollution:** Germination rates range from 20-60%, resulting in thinner and shorter seedlings compared to the control group.
4. **Heavy Pollution:** Seed germination is markedly weakened, with rates below 20%. Seedlings in this condition are notably small in size.

Results and discussions

During the observation period spanning 5-7 days, we meticulously monitored seed germination and plant root development. Additionally, we supplemented the substrates with meltwater sourced from snow collected at the respective sites, as they dried.

On the second day of observation, noticeable swelling of the seeds was observed, accompanied by the onset of germination. By the fourth day, sprouts began to emerge, displaying visible growth in size. Over the subsequent three days, there was a significant increase in the size of the sprouts, coupled with the onset of chlorophyll synthesis as evidenced by the transition to a green hue (Figure 5). These observations indicate successful germination and early growth stages of the plants under investigation.

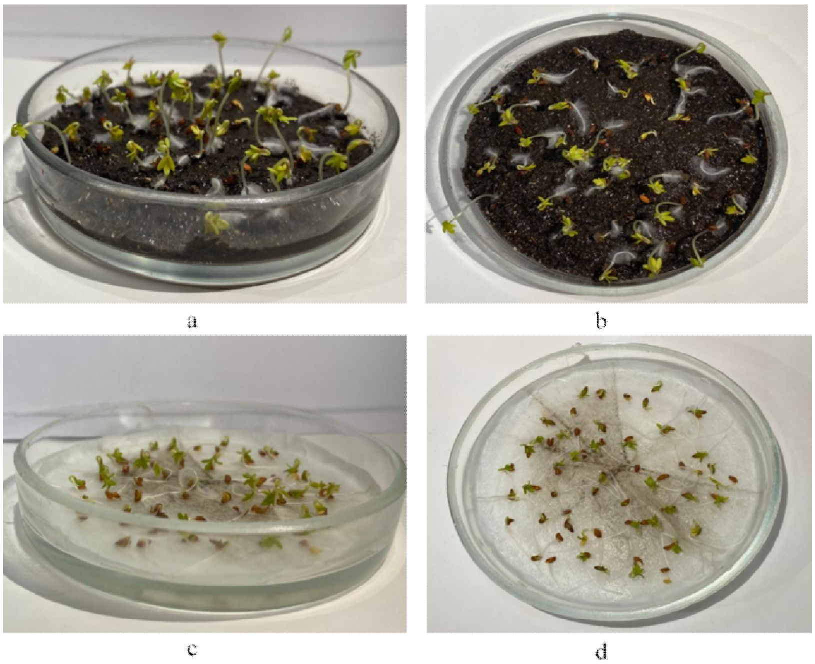

Figure 5 – a, b) The Petri dish with filter paper; c, d) The Petri dish with soil

Subsequently, we proceeded to observe the contamination process, utilizing a microscope with 40x magnification. Through this examination, we discerned the intricate interplay of various contaminants. Notably, we observed the intertwining of fungal hyphae and bacterial colonies, a phenomenon attributed to factors such as inadequate air circulation and moisture levels. This process underscores the susceptibility of seedlings to infection by phytopathogens, as depicted in Figure 6.

a b

Figure 6 – a) The contamination process; b) Contamination under the microscope

Furthermore, the rapid proliferation of mold fungi on the surface of seeds precipitates a significant decline in germination rates, ultimately leading to seed spoilage. Recent analyses have focused on quantifying the number of germinated seeds and the total length of roots cultivated in both soil and filter paper substrates. These observations have been graphically depicted, revealing noteworthy trends. Specifically, figure 7 illustrates that the maximum shoot length was recorded near Pugachev's Road (9.2 cm) and Victory Square (11.3 cm). Remarkably, these areas also exhibited the highest count of germinated seeds.

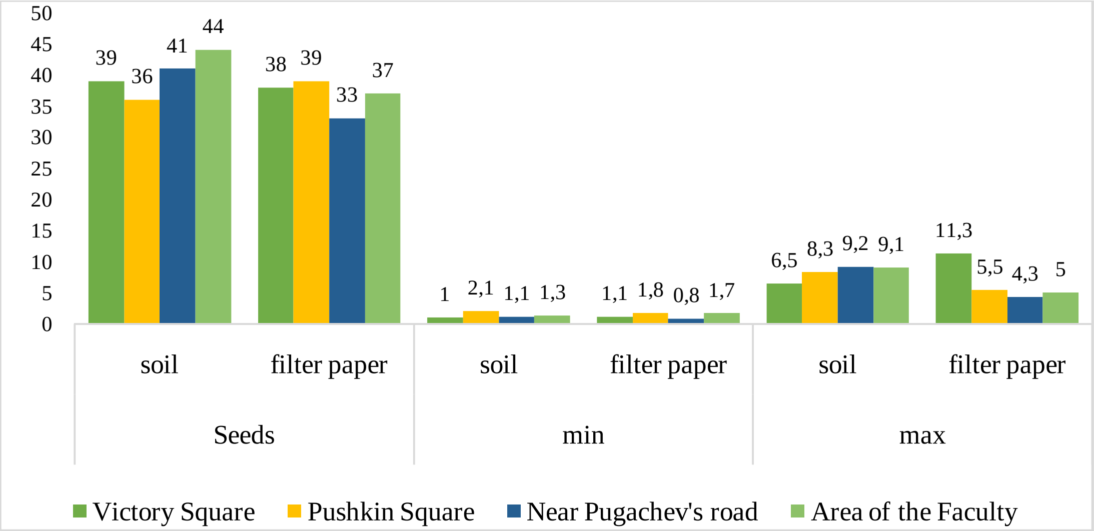

Figure 7 *Analyses of germinated seeds*

In our experimental investigations, we also scrutinized the germination dynamics of *Lepidium sativum* seeds, with the findings delineated in figure 8. Through this analysis, discernible trends emerged. Notably, all samples exhibited a reduction in germination rates compared to the control group.

Upon closer examination of the data, it becomes apparent that the percentage of *Lepidium sativum* seed germination varied across different sampling locations. Specifically, in Victory Square, the germination rate stood at 77%, followed by Pushkin Square at 75%, Pugachev Road at 74%, and the vicinity of the Faculty of Natural Geography at 81%. Despite the reduced germination rates, seedlings in these areas displayed characteristics indicative of normal growth—namely, they exhibited normal length, smooth surfaces, albeit with a slightly thinner appearance.

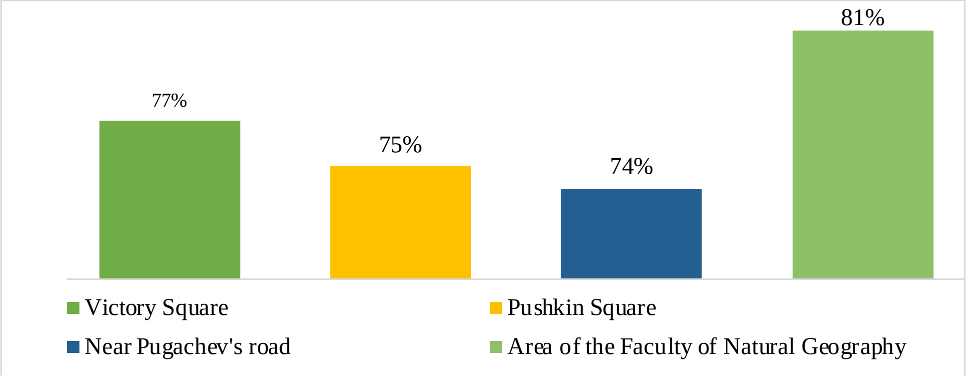

Figure 7 *- Assessment of the purity of atmospheric air*

Consequently, our study aimed to delineate the impact of pollutants on the growth and development of *Lepidium sativum* seedlings. Upon careful analysis of the data, it can be inferred that pollution levels within the city of Uralsk are relatively low.

Conclusion

In this study, *Lepidium sativum* served as a focal point for assessing air pollution, showcasing its efficacy as a bioindicator for evaluating environmental quality. Snow, acting as a reservoir for pollutants, contains significant amounts of solid particles such as dust and dirt, with its composition varying depending on the pollution source.

Lepidium sativum's sensitivity to environmental shifts, coupled with its rapid seedling emergence within 3-5 days, renders it an ideal bioindicator. As the plant matures swiftly, it accumulates pollutants within its tissues and organs. By irrigating with meltwater sourced from different locales, we discerned that areas proximate to Pugachev's Road exhibited heightened toxicity levels. The dense vehicular traffic in this region releases copious exhaust emissions and heavy metal salts into the atmosphere. Furthermore, it is plausible that pollution sources include boiler houses and industries in the fuel and energy sector.

The observed morphological aberrations in *Lepidium sativum* seedlings, notably the diminished root length and mass, underscore the deleterious impact of pollutants. This highlights the inherent danger posed by their release into the environment in their unmitigated form.

In sum, the versatility, sensitivity, and ease of cultivation of *Lepidium sativum* render it an invaluable asset in environmental science, facilitating efforts in environmental protection and conservation.

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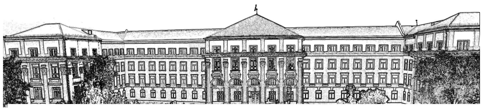
КРЕСС-САЛАТ (LEPIDIUM SATIVUM L.) АУАНЫҢ ЛАСТАНУЫН БАҒАЛАУ БИОИНДИКАТОРЫ ЕТІНДЕ

Аңдатпа. Бұл зерттеу ауаның ластану деңгейін анықтау үшін биоиндикатор ретінде кресс-салат (Lepidium sativum) өсімдігін пайдалануға ерекше назар аудара отырып, қоршаған орта сапасын бағалаудағы биоиндикацияның маңыздылығын зерттеуге бағытталған. Биоиндикация-бұл тірі организмдерді қолдана отырып, қоршаған ортаны бағалаудың қарапайым және жылдам әдісі. Топырақ пен ауаның ластануына сезімталдығымен танымал кресс-салат тұқымдарының тез өнуі мен ластаушы заттардың әсерінен айтарлықтай морфологиялық өзгерістерді көрсетеді. Зерттеу әдістемесі қоршаған ортаны ластаушы заттарды және олардың өсімдіктердің өсуіне әсерін бағалау үшін био-тестілеу, қар үлгілерін алу және өсімдіктің өсіп-өнуін қамтиды. Нәтижелер әртүрлі сынама алу орындарындағы ластанудың әртүрлі деңгейлерін көрсетеді, ластаушы заттар қардың қышқылдығының жоғарылауына ықпал етеді және тұқымның өну жылдамдығына әсері бар. Зерттеу кресс-салаттың биоиндикатор ретіндегі тиімділігін көрсетеді, оның тез өсуіне және қоршаған ортаның өзгеруіне сезімталдығына баса назар аударады. Сайып келгенде, бұл зерттеу ластаушы заттардың өсімдік экожүйелеріне әсерін түсінуге ықпал етеді және қоршаған ортаны қорғау және сақтау шараларының маңыздылығын көрсетеді.

Кілт сөздер: Кресс-салат (Lepidium sativum); биоиндикатор; үлгілер; ауа ластануы; тест-объект.



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КРЕС-САЛАТ (LEPIDIUM SATIVUM L.) КАК БИОИНДИКАТОР ДЛЯ ОЦЕНКИ ЗАГРЯЗНЕНИЯ ВОЗДУХА

Аннотация. Это исследование направлено на изучение значения биоиндикации в оценке качества окружающей среды, с особым вниманием к использованию кресс-салата (Lepidium sativum) в качестве биоиндикатора для определения уровней загрязнения воздуха. Биоиндикация представляет собой простой и быстрый метод оценки окружающей среды с использованием живых организмов. Кресс-салат, известный своей чувствительностью к загрязнению почвы и воздуха, демонстрирует быстрое прорастание семян и заметные морфологические изменения при воздействии загрязнителей. Методология исследования включает биотестирование, отбор образцов снега и тестирование на прорастание для оценки загрязнителей окружающей среды и их воздействия на рост растений. Результаты показывают различные уровни загрязнения в различных местах отбора образцов, при этом загрязнители способствуют повышению кислотности снега и влияют на скорость прорастания семян. Исследование подчеркивает эффективность кресс-салата в качестве биоиндикатора, акцентируя его быстрый рост и чувствительность к изменениям окружающей среды. В конечном итоге это исследование способствует пониманию воздействия загрязнителей на растительные экосистемы и подчеркивает важность мер по защите окружающей среды и ее сохранению.

Ключевые слова: Кресс-салат (Lepidium sativum); биоиндикатор; образцы; загрязнение воздуха; тест-объект.