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# APPLICATION OF THE BIOCATALYTIC DISPERSANT "NONTOX" FOR DECOMPOSITION OF OIL PRODUCTS IN CASE OF EMERGENCY SPILLS

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**Annotation:**

The article examines the prospects for using the biocatalytic dispersant Nontox to eliminate emergency oil spills, taking into account international experience. The composition, mechanisms of action, combining physical-chemical and biological processes, as well as versatility and efficiency in difficult conditions (low temperatures, high salinity of water) are analyzed. Particular attention is paid to the need to adapt the regulatory framework of Russia for the integration of hybrid technologies at the early stages of liquidation
spills.

**Key words:** biocatalytic dispersant, hybrid bioremediation technologies, low-temperature biodegradation.

# APPLICATION OF BIOCATALYTIC DISPERSANT "NONTOX" FOR DECOMPOSITION OF PETROLEUM PRODUCTS IN EMERGENCY OIL SPILLS

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**Abstract:** This study explores the potential of the biocatalytic dispersant "Nontox" for oil spill response, drawing on international experience. The paper examines its dual-action mechanism, combining physical-chemical dispersion and biological processes, as well as its versatility and efficiency in challenging environments, such as low temperatures and high salinity. Special attention is given to the need for regulatory adaptation in Russia to facilitate the early-stage deployment of hybrid technologies in spill mitigation.

**Key words:** biocatalytic dispersant, hydrocarbon bioremediation, hybrid remediation technologies, low-temperature biodegradation.

## 1. Introduction

Accidental oil spills create large-scale environmental threats, affecting ecosystems and populations in emergency situations. Oil and oil products are the most common pollutants in the world.

ocean [1]. Thus, the fuel oil spill in the Kerch Strait on December 15, 2024, caused by the sinking of the tankers Volgoneft-212 and Volgoneft-239, led to the pollution of more than 400 km² of the Black Sea and the release of about 5 thousand tons of fuel oil.

Fuel oil and other petroleum products spread across the surface of the water, settle to the bottom in the form of heavy fractions, and pollute the beaches. In addition, fuel oil coats the feathers of birds and the skin marine life, leading to death. In addition to the environmental impact, oil spills pose a threat to public health: the vapors contain volatile organic compounds such as benzene, toluene, xylene, and ethylbenzene, which can cause headaches, nausea, and chronic respiratory diseases [2]. The variety of contaminated surfaces (sea water, sandy beaches, rocks, soil, bird feathers, and animal skin) complicates the adoption of comprehensive measures without a universal approach.

According to GOST R 57447-2017 [3], the process of cleaning contaminated areas is divided into two stages: technical and biological. The technical stage is based on mechanical methods, such as the use of booms, sorbents and removal of contaminated soil. However, these methods are difficult in remote areas, and the high costs of transporting and disposing of contaminated soil make the process expensive. Moreover, the removal of large volumes of soil can damage the vulnerable ecosystem of coastal zones. At the first stage, physicochemical methods are also used, including the dispersion of dispersants. However, their toxicity threatens ecosystems and their use is limited according to GOST R 56024-2014 [4].

In this regard, most domestic solutions are focused on the second - a biological stage that involves the introduction of live microorganisms or the addition of biocatalysts to stimulate microorganisms that decompose hydrocarbons. However, the efficiency of the method decreases by 60–70% at +5°C, which makes this method ineffective in cold regions and seawater with high salinity [5].

These limitations highlight the need to find new solutions that can combine efficiency, versatility and environmental safety. The most promising areas are combined technologies that combine physical, chemical and biological mechanisms of action [5]. They allow overcoming the shortcomings of traditional methods, ensuring rapid and environmentally safe elimination of spills. Hybrid methods that simultaneously emulsify oil and stimulate its biodegradation are actively developing in global practice [6].

Such methods are based on the use of biodispersants of natural origin, which eliminates toxicity [7]. Unlike mechanical collection of contaminated soil, biodispersants allow working with contamination directly in the accident zone. They are completely biodegradable and environmentally safe [8]. Moreover, they are effective at low temperatures [9], which is relevant for use in the difficult climatic conditions of Russia.

The purpose of this article is to study the efficiency of biocatalytic dispersant "Nontoks" for decomposition of petroleum products, evaluate its use in emergency situations and offer recommendations for its implementation in Russian practice. The study is based on a review of laboratory and field tests, as well as an analysis of its technical characteristics. Particular attention is paid to the issues of adapting the technology to the regulatory framework of the Russian Federation, which will speed up the use of the solution in the elimination of oil spills.

**2. Composition and mechanism of action of "Nontox"**

**2.1 Composition of the Nontox solution**

The biocatalytic dispersant Nontox, developed by Bio-Organic Catalyst Inc., is a hybrid technology for eliminating the consequences of oil spills. The liquid agent combines the properties of a dispersant and a biocatalyst [6]. Its base (89.5%) is a yeast extract with amino acids and peptides necessary for the metabolism of microorganisms that decompose hydrocarbons. The extract stimulates autochthonous microflora, accelerating the degradation of petroleum products [6].

The supplement includes nonionic surfactants (surfactants, 10%), represented by ethoxylated alcohols C11-15 and C12-14. They have good biodegradability and low toxicity for aquatic ecosystems, being safer for the environment than anionic and cationic surfactants. The absence of living microorganisms in the composition emphasizes that Nontox acts as a catalyst and stimulant, and not an independent bioagent.

Table 1. Composition of the biocatalytic dispersant "Nontox".

| Name of the substance | Substance Identifier | % |
|---|---|---|
| Yeast extract of Saccharomyces culture cerevisiae | (CAS number) 68876-77-7<br>(EC Number) 614-750-7 | > 89.5 |
| Alcohols, C11-15- secondary, ethoxylated, butoxylated | (CAS number) 68131-40-8<br>(EC Number) 614-295-4 | < 5.5 |
| Alcohols, C12-14- secondary, ethoxylated | (CAS number) 84133-50-6<br>(EC Number) 617-534-0 | <4 |
| Hydrocarbon-oxidizing microorganisms | Contains no living parts microorganisms | 0 |

The concentrate has an acidic pH (3.9–4.3), but after dilution in water, the working concentrations of the solution are characterized by a neutral pH range (6.3–6.9), which corresponds to natural environmental conditions and eliminates toxic effects on ecosystems [8].

**2.2 Mechanism of action of Nontox**

The mechanism of action of Nontox is based on sequential physicochemical and biological processes that stabilize and degrade petroleum hydrocarbons.

**1) Emulsification of hydrocarbons (physicochemical process)**

Nonionic surfactants "Nontox" are adsorbed at the oil-water interface. According to laboratory studies, even a low concentration of "Nontox" 40 mg / l (0.004%) reduces the surface tension of water to 29 mN / m [6]. The product disperses oil products, creating a temporary emulsion. In tests (2 ml of kerosene + 2 ml of solution), "Nontox" achieved an emulsification index (E24) of 74.47% ± 5.55, which exceeds the threshold of 40% for effective surfactants [6]. This reduces the evaporation of hydrocarbons, forming a hydrophobic barrier around the particles [9]. As a result, the smell disappears in minutes or hours. But if some of the volatile hydrocarbons have evaporated earlier, the smell may remain in the air for some time.

**2) Oxygen saturation (physicochemical process)**

Nontox helps enrich the environment with oxygen, creating aerobic conditions for oxidation and biodegradation. Laboratory tests conducted by the County Sanitation Service

Orange County, Costa Mesa, California, showed that the addition of Nontox increased oxygen levels to 2.78 mg/L in 30 minutes, 2.5 times faster than the control (1.02 mg/L) at a BOD of about 250 mg/L [9]. In another study, the addition of Nontox to aerated water samples containing Vasconia crude oil increased the removal efficiency of petroleum hydrocarbons mixed with seawater to 82%, compared to 20% in unagitated samples [6].

**3) Biocatalysis (physical and chemical process)**

Yeast extract activates catalysis, reducing the activation energy of hydrocarbon oxidation reactions. The enzymes and nutrients it contains initiate the primary destruction of the molecular framework of petroleum products, including paraffins and asphaltenes. This leads to the transition of high-molecular components to a freely dispersed state, reducing the viscosity of the system. The authors of the study, published in the journal Heliyon

It is suggested that Nontox organizes reaction platforms (clusters or bubbles), increasing the concentration of reagents and accelerating catalysis [6].

**4) Bioremediation (biological process)**

The final stage is the biodegradation of hydrocarbons by autochthonous microorganisms stimulated by yeast extract. The extract acts as an adaptogen, which is confirmed by the results of tests conducted at the University of California, Irvine. An increase in the number of non-pathogenic bacteria in seawater was shown by 143.33 times in 24 hours with the addition of 40 mg / l of Nontox. At the same time, the solution did not affect the growth of pathogenic bacteria, as demonstrated by the example of the growth of *E. coli bacteria.* [11]. At high TPH (> 10,000 mg / kg) and temperatures above 8 ° C, the addition of probiotics is recommended

(0.1%) to accelerate the process of decomposition of petroleum products.

**3 Synergistic effect of liquidation of petroleum products**

The combination of dispersion and biocatalysis accelerates and safely eliminates petroleum products, surpassing the effect of using only surfactants or biocatalysts. Combined action with mixing and additional aeration further accelerates the elimination of petroleum products.

**Degradation of petroleum hydrocarbons and phenols in the field:** At a concentration of 76 mg/l (0.01%), Nontox was used to clean liquefied petroleum gas tanks before discharge into natural waters. Turbidity decreased by 30% in 2 days, by 50% by day 8. Active degradation of organic matter was accompanied by foaming and a decrease in odor. After 8 days, the pollution level dropped to the standard. Aeration reduced the concentration of hydrocarbons from 1.6 mg/l by 99%, phenols from 0.66 mg/l by 94%, and pH increased from 5 to 8. Without aeration, the reduction in phenols was 72% [10]. The manufacturer also reports that, on average, TPH decreases from 80,000 to 500 mg/kg per month with active bioremediation with the addition of probiotics, but there is no confirming source.

**Laboratory Hydrocarbon Degradation Studies:** California-based environmental engineering firm CSU Chico used soil samples from a U.S. Air Force base to artificially contaminate with JP-7 aviation fuel to a concentration of 5,950 mg/kg. The experiment was maintained at 50% humidity and 20°C. Nontox resulted in 90% degradation of S-TPH from 88 mg/L to 8.4 mg/L in 28 days.

This is 3–4 times faster than in control samples, where decomposition was only 27%. The authors of the tests believe that with the addition of probiotics, the efficiency of degradation of petroleum products can be 10–20 times higher [11].

**Odour and infection vector reduction:** Nontox (2–3%) was sprayed daily on oil product filtrates at Colombian landfills (Florencia, Bogota, Risaralda). After 15 days, at the Florencia landfill, BOD (1850 mg/l) was reduced by 79%, COD (2680 mg/l) by 68%, and suspended solids (1200 mg/l) by 85%. At all landfills, odour was significantly reduced and the number of infection-carrying organisms was reduced by 60%. The treated water became suitable for irrigation without additional treatment [10].

## 4. Practical application of Nontox

Nontox demonstrates versatility in emergency situations, providing both instant dispersion and long-term decomposition of hydrocarbons. Its application covers water bodies, soil, landfills with contaminated soil, as well as washing off oil products from animal skin and bird feathers.

### 4.1 Dosage of "Nontox"

The thickness of the oil layer of the contaminated surface can vary significantly, which makes it difficult to accurately calculate the dosage. In any case, the application rate requires adjustment taking into account the specifics of the spilled oil and the dynamics of the change in the thickness of the oil slick under the influence of external factors.

1) **Water and soil treatment:** Nontox solution is used in concentrations of 1–5% with a single spray on the water surface: 1% for fresh oil, 5% for viscous fractions. For soil cleaning, a 5% solution is used in a volume of 1.3 l per 1 m³ of soil after preliminary loosening and moistening (25–35%).

2) **Addition of probiotics:** At high TPH levels (>10,000 mg/kg) or temperatures above 15°C, 0.1% probiotics are added, which reduces the degradation time of petroleum products from 6-12 months to 1-3 months. Repeated treatment (4-5% Nontox and 0.1% probiotics) is carried out after 15 days if necessary. However, the introduction of probiotics is not always justified and depends on the conditions. At low temperatures, the addition of probiotics is ineffective: microorganisms either do not survive or their activity remains minimal. In such cases, a 5% Nontox solution is first used to emulsify hydrocarbons and enrich the environment with nutrients from yeast extract. This creates favorable conditions for natural microflora and maintains the bioavailability of pollutants until the temperature rises. At consistently low temperatures and in the absence of warming, Nontox is used without probiotics, counting on a gradual

natural restoration of the ecosystem.

3) **Cleaning of animal skin and bird feathers:** Nontox at a concentration of 2% at a temperature of 20–40°C safely removes oil from animal skin and bird feathers. The solution is applied manually or with low-pressure sprayers, which minimizes stress on animals. The method is simple, effective and safe for both humans and animals. Acute toxicity tests show LC50 > 10,000 mg/kg with no adverse effects for 168 hours. For marine organisms such as Mysidopsis bahia (invertebrates) and Menidia beryllina (vertebrates), tests have shown that the substance has very low toxicity in the marine environment [12].

**4) Treatment of contaminated soil at landfills:** 5% solution with probiotics accelerates the processing of contaminated soil. Spraying is carried out daily or at intervals of 5 days. The solution is applied using sprayers or irrigation systems after loosening the soil, maintaining the moisture level within 25-35%. The smell of petroleum products disappears within 24 hours. The method is especially effective for local landfills and settling tanks.

**5) Application time window after spill:** The effectiveness of Nontox decreases with increasing oil viscosity, which occurs when the oil weathers. The optimal application period is from several hours to several days, depending on the type of oil and conditions.

### 4.2 Application methods

**1) Shoreline cleaning application:** Nontox solution is applied using hand-operated sprayers. Working concentrations of the solution vary between 1-5% diluted in water. Dilution can be done before spraying or by adjusting the settings of the spray equipment. A portable pressure washer with a pressure of 125-150 bar and a flow rate of about 400 l/h is ideal for applying Nontox solution.

**2) Spraying from boats:** Boats with nozzles (150 bar) cover up to 500 m² per pass. The dispersant is supplied by diesel or electric pumps through nozzles on remote consoles, providing a uniform spray of drops. The devices can be portable or stationary. The consoles are more effective if located closer to the bow of the boat to avoid throwing off oil. The use of boats allows for precise application of dispersant to target areas.

areas of the spot.

**3) Aerial spraying:** Seaplanes, helicopters and drones spray the solution at an altitude of 15-30 m, treating up to 1000 m² at a speed of 25-75 m/s. Efficiency depends on the reaction time (24-48 hours) and the accuracy of the application. Coordination with drones can improve accuracy, but requires additional resources.

### 4.3 Storage, logistics and foreign trade regulation

The Nontox solution is produced abroad and certified in Canada, the USA and Europe.
[10]. The distribution company Nanoresonance Industries delivers it from Europe within 10 days [13]. For long-term storage, it is best to use plastic barrels.
or tanks. If the storage conditions are met, the solution remains suitable for two years. After opening the container, the effectiveness of the product is checked periodically. Import of Nontox to Russia does not require mandatory certification according to TN VED 3402.42.0000.

## 5. Advantages of using Nontox

**Environmentally friendly and biodegradable:**

1) Nontox is safe for humans and does not cause toxic effects in aquatic organisms, both freshwater and marine. The LC50 results are 203–316.23 mg/l, which is significantly higher than that of common dispersants (e.g. Corexit LC50 ~10 mg/l) [12].

2) Completely biodegradable (>75% in 28 days, OECD 302B) [12], unlike dispersants containing toxic components that may not decompose over time several months or even years.

3) Stimulates the growth of natural oil-oxidizing bacteria without increasing the number of pathogens such as E. coli [11].

**Versatility and wide applicability:**

4) Helps in the elimination of crude oil, fuel oil, creosote, kerosene, coal resins, gasoline, diesel fuel, bunker fuel, lubricants and hydraulic liquids, drilling mud, phenols [11].

5) Works both on water and on land (soil, sand, hard surfaces, equipment, transport) [10].

6) Can be used to clean bird feathers and animal skin, which is critical in case of oil spills [10].

7) Provides rapid removal of volatile and soluble petroleum hydrocarbons, whereas classical dispersants and biocatalysts are less effective individually [11].

8) Suitable for cleaning filtrates and contaminated soil at landfills [10]. **Efficiency in difficult conditions:**

9) Works in a wide temperature range (2°C – 55°C), preparing the substrate even at low temperatures [10].

10) Remains effective in high salinity seawater [11], which is especially important for use in regions with high water mineralization (for example, the Black Sea).

**Ease and safety of use:**

11) Completely soluble in water (100%) and compatible with standard sinks (500 bar), which simplifies application [10].

12) Does not require special personal protective equipment (PPE), as it is not toxic or chemically hazardous (confirmed by safety certificates from Canada, the USA and Europe) [10].

**Logistics and storage convenience:**

13) Concentrate 100% and ultra-concentrate 400% are supplied in plastic barrels (208 liters) and tanks (1040 liters).

14) Remains effective for two years when sealed and then subject to periodic testing [10].

**Economic efficiency:**

15) On average, it reduces cleaning time by 4 times and reduces costs by 50% compared to traditional methods [11].

16) Reduces the volume of contaminated soil and oil sludge removed, reducing transportation and disposal costs [11].

Thus, the key advantages of Nontox include accelerated decomposition of petroleum products without the need to remove contaminated soil, effective odor neutralization, and a significant reduction in the time of bioremediation of ecosystems. This makes it especially valuable in emergency rescue operations, allowing for prompt

minimize the impact of oil spills by outperforming alternative approaches
speed and environmental friendliness.

**6. Suggestions for the timely use of Nontox in Russia**

The timely use of the biocatalytic dispersant Nontox in Russia faces a number of obstacles related to the regulatory framework, organizational restrictions and insufficient adaptation of existing standards to modern

technologies.

**6.1 Additions to GOST**

GOST R 57447-2017, which regulates the reclamation of land contaminated with oil products, is the main tool for a systematic approach to the restoration of territories [3]. However, in the current version, the standard is focused primarily on traditional methods and does not take into account hybrid technologies. Products based on biological components, such as Nontox, are considered primarily as bioremediation tools and their use is assumed at the second stage of reclamation -

stage of biological restoration. Meanwhile, Nontox is not only a biocatalytic solution, but also a dispersant. It is effective already at the first stage
spill response and its timely use is critical to minimizing
pollution.

In this regard, it is proposed to supplement GOST R 57447-2017 with provisions that would take into account the use of biocatalytic dispersants, such as Nontox, at the initial stage of liquidation. This could contribute to the faster decomposition of petroleum products and
reducing the load on subsequent stages of reclamation.

GOST R 56024-2014 regulates the selection of methods for eliminating oil and oil product spills at sea, including dispersants [4]. The standard requires an assessment of the environmental safety and effectiveness of dispersants in specific conditions to minimize the impact on the environment. The drug "Nontox" is based on biological components

and therefore differs from traditional chemical dispersants. However, the lack of indication in the standard of the applicability of such biological hybrid agents may lead to their classification as potentially hazardous, which will make it difficult to promptly agree with

environmental supervision authorities and, as a consequence, to the refusal of use at sea.

In this regard, it is proposed to supplement GOST R 56024-2014 with provisions clarifying
the possibility of using biocatalytic dispersants such as Nontox, with an emphasis on their dual action and environmental safety. And also, to develop a simplified assessment procedure for products with proven biodegradability in order to accelerate their use in emergency situations without harming ecosystems.

**6.2 Preparing the infrastructure**

It is suggested:

- Create infrastructure and prepare equipment (sprayer guns) for application
  solutions.
- Organize the storage of complex action solutions in ports, terminals and
  on ships.

• Organize training for employees of the Ministry of Emergency Situations and environmental services in methods of working with biodispersants, including spraying and monitoring the results.

**Conducting pilot projects**

Despite the potential for the use of Nontox in Russia, there are no publicly available data on large-scale tests confirming its effectiveness in various conditions (on the ground, in the marine environment, in cold climates) at high concentrations of TPH petroleum products (>10,000 mg/kg). In 2021, Gazprom Neft tested the Nontox solution in Khanty-Mansiysk, but the research results belong to a private company and are not subject to disclosure. This limits access to an objective assessment of the technology, reduces trust on the part of regulatory authorities and complicates its implementation. In this regard, it is proposed to conduct pilot projects to assess the effectiveness of Nontox and develop adapted protocols for its use.

## 7. Conclusion

Analysis of the biocatalytic dispersant Nontox confirms its high potential in eliminating emergency spills of oil products. This multifunctional agent combines physical, chemical and biological processes, accelerating emulsification, oxygenation and biodegradation of hydrocarbons. Its environmental safety, resistance to various conditions and lack of toxicity make it an effective tool for rapid response in emergency situations.

Laboratory and field tests confirm its effectiveness in decomposing various petroleum products, including Vasconia crude oil. Industrial use of Nontox in liquefied petroleum gas tanks and landfills containing petroleum product filtrates allows for significant reduction in pollution levels, elimination of odors, and use of purified water for irrigation without additional treatment.

Its key advantages include effectiveness even at low temperatures and in salt water, versatility in various environments (water, soil, animal skin) and ease of use. These properties are especially important for emergency situations in cold climates, such as the fuel oil spill in the Kerch Strait in December 2024.

Maximum efficiency is achieved with prompt use of Nontox in the first days after a spill. However, the introduction of such technologies into Russian practice is complicated by the imperfection of the regulatory framework (GOST R 57447-2017 and GOST R 56024-2014), which does not take into account the specifics of hybrid solutions. Successful implementation requires revision of standards, development of infrastructure and large-scale field testing in Russian conditions. With an integrated approach, Nontox can significantly increase the efficiency of oil spill response, reducing environmental and economic consequences.

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**Review of NONTOX efficiency based on the published article**

by the Scientific Board for Environmental Remediation

January 2025
Moscow, Russia

**The title of reviewed article:**

Effectiveness of a bio-catalytic agent used in the bioremediation of crude oil-polluted seawater" by Glenda Teran-Cuadrado and Efrain Polo-Cuadrado (Heliyon 7, 2021, e06926).

**Review**

The experimental setup included six samples:

A: Seawater with oil (640 mg/L, control without bio-catalyst and aeration).

B: Seawater with oil (640 mg/L) and Nontox (2167 mg/L), no aeration.

C: Seawater with oil (640 mg/L) and Nontox (10,000 mg/L), no aeration.

D: Seawater without oil, with Nontox (2167 mg/L) and aeration.

E: Seawater with oil (640 mg/L), Nontox (2167 mg/L), and aeration.

F: Seawater with oil (640 mg/L), Nontox (10,000 mg/L), and aeration.

**Why this study fails scientific conclusions:**

1. **Inadequate control samples:**
    1) No control with oil and aeration but without Nontox, preventing isolation of the bio-catalyst's effect from aeration's contribution.
    2) Sample D (no oil) is irrelevant for TPH removal, weakening the control framework.
2. **Incomplete data reporting:**
    1) Raw data (e.g., TPH concentrations over time) and figures are referenced but not detailed, hindering independent assessment.
    2) TMC data is mentioned but not presented, leaving microbial contributions unverified.
3. **Overstated conclusions:**
    1) Qualitative tests (drop-collapse, oil-spreading) confirm surfactant properties but not bioremediation efficacy in seawater.

2) Effectiveness claims rely heavily on Sample F (10,000 mg/L Nontox with aeration), but without isolating variables or statistical validation, they are inconclusive.

**Recommendations for improvement:**

1. Include a control with oil and aeration (no Nontox) to isolate variables.
2. Test Nontox concentrations systematically across all conditions.
3. Perform statistical tests and report full error margins.
4. Increase replicates (e.g., 3 vessels per condition).
5. Analyze degradation products and microbial dynamics.
6. Simulate real-world conditions for broader relevance.

**Conclusion**

- The study is not conclusive in proving Nontox's effectiveness for bioremediation. Sample F (10,000 mg/L Nontox with aeration) achieved 81.537% TPH removal compared to ~20% in non-aerated samples (A, B, C). However, without an aeration-only control, the bio-catalyst's specific contribution versus aeration remains unproven.
- The control (A, oil only) shows minimal natural degradation over 30 days, but the lack of statistical validation and incomplete controls renders the results suggestive rather than definitive.
- Qualitative tests confirm surfactant activity but do not directly prove bioremediation efficacy in seawater.

In conclusion, while the study hints at Nontox's potential, its scientific conclusions are compromised by inadequate controls, poor statistical analysis, and incomplete reporting, as assessed by the Scientific Board for Environmental Remediation in Russia.