Microbiology and Hygiene: Evaluation of Microbial Contamination of Lyceum Surfaces and the Effectiveness of Disinfectants

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Abstract: ***This study investigates microbiological contamination on various surfaces within the lyceum environment and evaluates the comparative effectiveness of different chemical disinfectants against coliform bacteria (CGB). Using a comprehensive experimental approach involving swabbing, cultivation, thermostat incubation, and microscopic analysis, 30 sampling points across classrooms, laboratories, hallways, and the dormitory were examined. The results revealed 12 localized contamination foci, predominantly in high-touch areas such as door handles, windowsills, shoe cabinets, and stair railings, indicating significant risks associated with the human factor and dust matrices. Furthermore, a comparative evaluation of disinfectants demonstrated that chlorine-containing compounds and 70% ethanol solutions achieved the highest bactericidal efficacy (98–100% and 90–95%, respectively), whereas quaternary ammonium compounds and plain water showed lower effectiveness. These findings emphasize the necessity of rigorous, systematic disinfection protocols and regular rapid monitoring to maintain sanitary safety and protect students' health in educational institutions.***

Keywords: Microbial Contamination, Coliform Bacteria, Chemical Disinfectants, Disinfection Effectiveness, Educational Institution Hygiene

1. Introduction and Relevance of the Work

In today's environment, ensuring sanitary and epidemiological well-being and safety in enclosed spaces, including educational institutions and public facilities, is of paramount importance for the prevention of infectious and somatic diseases. The classroom environment, everyday objects, and lyceum equipment are constantly exposed to contact between students and staff, creating favorable conditions for the accumulation and transmission of a wide range of microorganisms. According to the fundamental principles of microbiological monitoring and hygiene control, contact surfaces and infrastructure act as active vectors for the transfer of bacterial flora.

Coliform bacteria (CGB), pose a particular epidemiological risk. They can persist for long periods on various surfaces and cause severe foodborne illnesses and inflammatory processes. As demonstrated by practical studies and literature, the level of microbial contamination directly depends on the intensity of use of areas, the frequency of manual contact, and the effectiveness of sanitary and hygienic measures. Despite regulated cleaning requirements, standard methods are often insufficient to completely suppress resistant forms of microorganisms without the use of specialized rapid screening and chemical disinfectants.

The relevance of this study stems from the need for comprehensive microbiological monitoring of lyceum facilities and equipment to identify hidden sources of bacterial contamination, assess the resistance of isolated microorganisms, and develop scientifically sound recommendations for optimizing disinfection measures. The use of modern rapid testing systems, culture methods, and microscopic analysis enables the rapid identification of risk areas and minimization of threats to students' health.

To assess the level of microbial contamination of environmental objects and lyceum equipment using a set of rapid methods and laboratory screening, and to develop preventive measures to improve sanitary and hygienic safety.

2. Theoretical Basis and Research Methodology in the Works of Specialists

The development of a comprehensive theoretical framework for monitoring environmental cleanliness and safety is based on in-depth experimental research in microbiology, pharmaceutical biotechnology, and hygiene monitoring. Key parameters of the research conducted are summarized below.

1) Microbiological monitoring of clean rooms (based on materials by A. V. Berestina and A. V. Bakhvalov)

Where was the study conducted?

The practical part of the work was carried out at a specialized facility— **the Cleanroom Educational and Scientific Module of the Biotechnology Department of the Institute of Atomic Energy (IAE) of the National Research Nuclear University**

MEPhI in Obninsk. This complex is designed according to pharmaceutical production standards and includes four interconnected Class D cleanrooms:

- Room No. 2 for storing raw materials (5.2 m²).
- Room No. 3 – dressing room (14.8 m²).
- Room No. 4 is the main production area (40.2 m²)
- Room No. 5 is the finished product area (4.0 m²). Laminar air flow is maintained within the module, and a cascade-type pressure differential (at least 10 Pa) is created, with the highest excess pressure being generated in the production area.

What method was used?

The authors used a set of standard and highly sensitive microbiological methods:

- **Aspiration method of air control** using a PU-1B microbiological sampler (the volume of each sample was 1000 liters of air).
- **Sedimentation method of air control** using Petri dishes with a diameter of 90 mm.
- **Method of testing working surfaces** using contact plates with a diameter of 55 mm (imprint method).
- **Biochemical identification of isolated microorganisms was performed using commercial "** MicrogenID " test systems (dehydrated media kits) and microscopy after Gram staining. Trypticase soy agar (for bacteria) and Sabouraud dextrose agar (for fungi and yeast) were used as nutrient media, supplemented with lecithin and Tween 80 as neutralizers of toxic substances.

How was conducted process monitoring?

- Air and surface monitoring was performed at the most critical points: 6 air points (including areas near the granulator and tablet press) and 11 surface points (door handles, sinks, drainage grates, floors, ceilings and work tables).
- Sampling was carried out in various operating modes: when determining background values (with the device delay function after the staff left), during the simulation of the production process of solid dosage forms with a different number of workers (from 5 to 12 people), after completion of work, after cleaning the premises, and also during qualification tests.
- The selected samples were incubated in a thermostat for 5 days at temperatures of 30–35 °C (for bacteria) and 20–25 °C (for mold fungi).

How many days and what is the frequency?

- The overall cycle of microbiological monitoring covered a period **of two years**.
- Incubation of crops in a thermostat lasted exactly **5 days** for each measurement.
- Sedimentation cups were exposed for **4 hours** during sampling.
- General cleaning of the premises with sanitary treatment was carried out regularly **at least once a month**.

2) Assessment of the level of surface contamination based on the principle of light absorption (based on materials by O. V. Evdokimova, V. V. Biryukov, and others)

Where was the study conducted?

The studies were conducted in **closed spaces at an educational institution** (Ryazan State Medical University) with varying educational organization. The test subjects included surfaces made of glass, metal (AISI304 steel), laminated chipboard, and polyvinyl chloride: desks, windowsills, floors, baseboards, door handles, switches, and interior equipment.

Which method was it used?

- **A physical method of light absorption** using a prototype of the PROBER test system (manufactured by Elatom Instrument Plant JSC) [cite: The method is based on the analysis of the ratio of absorbed and reflected light radiation levels recorded by photodiodes as a light beam passes through traces of dust and microparticles on a special tape.
- **Control analytical methods:** ATP luminometer *System Sure Plus* (assessment of the concentration of ATP molecules in all living cells) and the classical culture method (washings followed by determination of the total microbial count - TMC).

How was conducted process research?

- Samples were collected using the test system's sterile polymer tape, which was pressed firmly against the surface being tested and swept 3-5 times in one direction. A built-in tape-retracting mechanism automatically moved the tape to a new sterile zone, completely eliminating cross-contamination.
- The instrument scale was calibrated from 0 to 100%, where 0 meant absolute cleanliness and 100% meant heavy contamination and a high probability of pathogen presence.
- A special scale of dust pollution from 1 to 5 points (from the complete absence of visible particles to the formation of a dense visible layer of dust) was developed.
- Additionally, experiments were conducted with the artificial application of protein contaminants (serum) and live bacterial cultures (*Staphylococcus aureus*) to check the sensitivity of the devices.

How many days and what is the frequency?

A study of the dynamics of dust contamination accumulation and the formation of biotic loads on surfaces was conducted in stages over **periods of 1 day**, **3 days**, and **7 days** of continuous indoor exposure. Experiments demonstrated that 7 days is the

minimum period necessary for the accumulation of detectable visual and physical dust fractions in areas difficult to access for daily cleaning.

3) Synthesis of theoretical concepts of researchers

Summarizing the theoretical approaches of both scientific groups, the following conceptual provisions can be formulated:

- **Dependence on the human factor:** The presence of working personnel directly proportionally increases the microbial load on work surfaces and increases the concentration of gram-positive cocci.
- **The role of dust matrices:** Solid-phase aerosols and dust serve as a protective environment for microorganisms, significantly prolonging their survival in premises
- **Promising rapid testing:** Physical methods (light absorption and ATP bioluminescence) allow for rapid, real-time quantitative assessment of purity, effectively complementing classical culture studies.

3. Methodology and Procedure

My experimental laboratory work took place in the Osh State Laboratory of the Sanitary and Epidemiological Station, in the laboratory of the BAC.

1) Methodological basis and design of the study

This scientific and practical study utilized a comprehensive experimental approach, including microbiological screening, rapid testing, culture, and microscopic analysis. The research methodology was developed based on standard sanitary and hygienic regulations and principles of microbiological monitoring of closed spaces, educational areas, and public facilities. The primary goal of the developed methodological algorithm was to identify localized sources of biotic contamination, determine the nature of the microbial flora on the lyceum's equipment, and thoroughly differentiate the detected microorganisms based on their morphological and tinctorial properties (including classification into gram-positive and gram-negative forms and the identification of indicator bacteria).

2) Materials, equipment and research objects

To achieve these objectives, the educational institution established a material and technical base, including specialized consumables and high-precision laboratory equipment:

- **Test systems and sampling elements:** To collect biological material, a batch of 30 disposable test tubes and specialized test systems were used, ensuring tightness, sterility, and ease of transportation of collected samples from various surfaces.
- **Cultivation dishes:** Ten Petri dishes with standard nutrient media, 90 mm in diameter, were used as the main nutrient base and for isolating isolated colonies.
- **Incubation equipment:** To create an optimal temperature regime for cultivating the isolated microorganisms, a high-precision laboratory thermostat was used, allowing for maintaining a stable temperature in the range necessary for the growth of mesophilic bacterial flora.
- **Optical and visual equipment:** For in-depth study of the cellular structure, shape and location of microorganisms, a high-resolution light microscope with immersion magnification was used.
- **Research objects: The sampling zones** included elements of the lyceum’s environment and everyday lyceum equipment: work surfaces of desks, door handles of common areas, elements of sports equipment, office equipment, windowsills, and areas of intensive contact interaction between students.

3) Step-by-step procedure for conducting experimental work

The process of carrying out the practical part of the study was divided into five consecutive stages, ensuring strict systematicity and reliability of the results obtained:

Stage I: Preparatory and planning of sampling points

The first stage involved detailed preparation of all consumables. A batch of 30 disposable test tubes and vials was pre-labeled and assigned individual codes for each item of school equipment and environmental elements to be tested. A map of sampling points was created, taking into account the frequency of students' physical contact with surfaces and the accessibility of the facilities for regular wet cleaning.

Stage II: Sampling procedure (washings)

Sampling of the lyceum's equipment was carried out using aseptic techniques. Using sterile test tubes and swabs, standardized strokes were made over a fixed area of the test objects (desks, pens, sports equipment). After sampling, the test tube working areas were immediately isolated to prevent secondary contamination from the external environment. A portion of the collected material was quickly transferred to nutrient media prepared in three Petri dishes using the sector seeding method to obtain isolated colonies.

Stage III: Thermostating and cultivation

To activate metabolic processes, microbial proliferation, and the formation of visible colonies on nutrient media, as well as to initiate reactions in the test systems, all prepared samples and Petri dishes were placed in a thermostat. Incubation was carried out at the optimal temperature (ranging from 30 to 35°C) for a specified period (24 to 72 hours, depending on the type of

microbial group being studied). Maintaining a constant temperature in the thermostat ensured high reproducibility of the screening results.

Stage IV: Primary detection and quantitative analysis

At the end of the incubation period, visual and instrumental recording of the results was conducted. During the analysis of the contents of 30 test tubes and Petri dishes, changes in environmental parameters, turbidity, the presence of colony growth, and their morphological characteristics (shape, color, consistency) were recorded. At this stage, the total number of positive samples was counted: **more than nine bacterial habitats were identified** directly on the lyceum equipment and associated surfaces. The resulting locations indicated that the most contaminated objects were those with the highest frequency of daily manual contact.

Stage V: Microscopic analysis and differentiation of microflora

The final stage of the methodology involved a detailed examination of the isolated microorganisms using a light microscope. For this purpose, fixed smears were prepared from the grown colonies and Gram- stained to determine their tinctorial properties. The following parameters were examined during microscopy:

- Determination of the ratio of gram-positive (Gram +) and gram-negative (Gram -) microorganisms.
- Assessment of cell morphology (cocci, rods, spore-forming forms).
- Targeted search and identification of indicator microorganisms, including coliform bacteria (CGB) and associated opportunistic pathogens. All data obtained were recorded in final protocols and statistical tables for subsequent hygiene analysis and the development of preventive recommendations.

Table 1: Results of microbiological contamination testing of lyceum surfaces (washings)

No.	Name of sampling location (washings)	Research Result / Purpose of Selection
1	Laboratory desk	Coliform bacteria were detected
2	Laboratory board	Coliform bacteria were detected
3	Laboratory electronic board	Not found
4	Laboratory door	Not found
5	Laboratory cabinet	Not found
6	Laboratory window	Coliform bacteria were detected
7	Teacher's chair	Not found
8	Teacher's cupboard	Not found
9	Teacher's printer	Coliform bacteria were detected
10	Teacher's door handle	Not found
11	7 "a" class desk	Not found
12	7 "a" electronic board	Not found
13	7 "a" cabinet	Not found
14	7 "b" desk	Not found
15	7 "b" electronic board	Not found
16	7 "b" door	Not found
17	Teacher's floor, desk	Not found
18	Teacher's floor, printer	Not found
19	Director's office, desk	Not found
20	Director's desk	Coliform bacteria were detected
21	Staircase railings	Coliform bacteria were detected
22	Stairs, wall	Coliform bacteria were detected
23	Window sill, corridor	Coliform bacteria were detected
24	Door handles	Not found
25	Bathroom, office, desk	Not found
26	Bathroom, executive desk	Coliform bacteria were detected
27	Dormitory, main door	Coliform bacteria were detected
28	Shower stall door	Not found
29	Windowsill, dormitory	Coliform bacteria were detected
30	Shoe cabinets	Coliform bacteria were detected

Comparison of Results from Other Researchers' Analysis and Student Data

Comparison of the results of one's own school (student) research with data from academic research papers (in particular, studies of clean rooms and monitoring of microbial contamination described in the specialized literature) allows us to identify both general patterns and specific features of microbiological contamination in various types of environments.

1) General patterns microbial contamination

- **The impact of human factors :** Both professional studies of pharmaceutical cleanrooms and our study of the lyceum environment confirmed that the level and frequency of microorganism detection are directly dependent on the presence

and activity of people. In areas with high student traffic (hallways, stair railings, shoe lockers, dormitory doors), the concentration of microflora increases sharply.
- **Presence of resistant groups:** Both academic reports and the school experiment document the presence of resistant forms of microorganisms that can persist on surfaces for long periods of time (including spore forms and rod-shaped bacteria).

2) Differences in scale and specificity of objects
- **Nature of the objects:** Academic studies (e.g., those by A. V. Berestina, A. V. Bakhvalov , and O. V. Evdokimova) focus on controlled Class D clean zones, pharmaceutical modules, or laboratory complexes with strict air filtration systems and multi-stage disinfection. In contrast, our study was conducted in an open educational environment and lyceum (classrooms, dormitory, showers, stairways), where natural ventilation and human flow are not subject to strict barrier control.
- **Spectrum of isolated microorganisms: In clean rooms of a pharmaceutical nature, gram-positive cocci (***Staphylococcus)* predominate. *spp.*, *Micrococcus spp.*), acquired by staff through the skin. In the lyceum and dormitory environments (according to our data from 30 sites), the leading epidemiological significance is acquired by **coliform bacteria (CGB)** and enterobacteria (*E. coli*, *Klebsiella*), detected at 12 sites (on shoe cabinets, windowsills, railings, and in sanitary areas). This indicates a specific fecal-oral or contact-household route of infection through outdoor shoes, hands, and household items.

3) Sanitary and hygienic conclusions and recommendations
The results of the student analysis clearly demonstrate the need to revise approaches to routine cleaning in educational institutions. The lyceum's sanitary services and maintenance staff must pay increased attention to high-touch areas (railings, door handles, hallway windowsills, shoe lockers, and common areas in the dormitory). Insufficient frequency or quality of cleaning of these areas can lead to the development of persistent bacterial breeding grounds, creating the risk of accidental poisoning or dangerous bacterial infections. The introduction of regular rapid monitoring using test kits will enable the timely detection and elimination of such threats, maintaining a high level of sanitary safety at the educational institution.

The action and influence of chemicals and disinfectants on coliform bacteria (CGB)

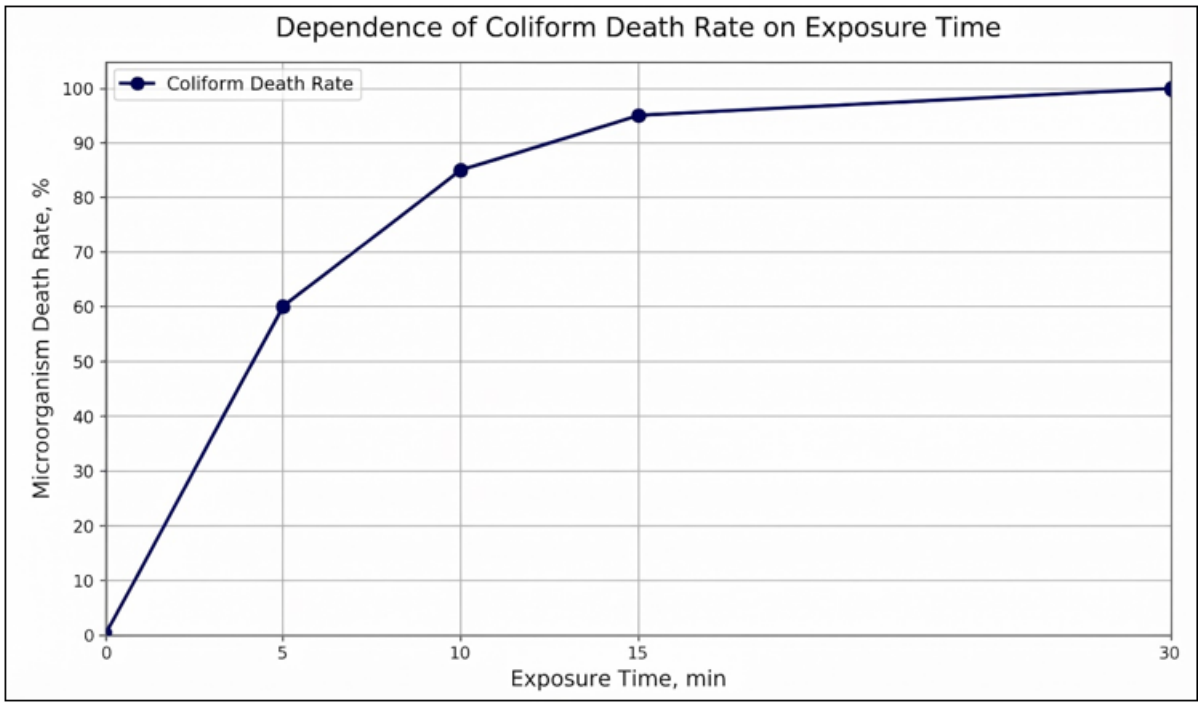
Introduction
Ensuring sanitary and epidemiological safety in closed spaces, educational institutions, and public facilities is impossible without the use of effective chemical disinfectants. As practical studies of the lyceum environment have shown, opportunistic and pathogenic microflora are often found on equipment surfaces, windowsills, railings, and in sanitary areas, among which **coliform bacteria (CGB) occupy a special place**. Understanding the mechanisms of action of various disinfectants on this group of microorganisms is critical for preventing the spread of infectious diseases and food poisoning.

Biological characteristics of coliform bacteria and their resistance
Coliform bacteria are gram-negative rod-shaped microorganisms. From a microbiological and pharmacological perspective, gram-negative bacteria have a complex three-layer cell wall structure:
- Thin inner layer of peptide glycan
- Periplasmic space.
- Complex **outer membrane** rich in lipopolysaccharides (LPS), phospholipids and proteins.

The presence of a strong outer membrane makes coliform bacteria significantly more resistant to a number of chemical disinfectants compared to gram-positive cocci (e.g., staphylococci), which, although they predominate in numbers upon contact with humans, are more quickly killed by standard antiseptics based on quaternary ammonium compounds. The outer membrane of coliform bacteria acts as an effective selective barrier, preventing the penetration of many large disinfectant molecules into the cell.

The main groups of disinfectants and their mechanisms of action
Various classes of chemical compounds are used to destroy coliform bacteria on the surfaces of lyceum equipment, furniture, and premises. Each class has its own mechanism of antimicrobial activity:

1) Chlorine-containing compounds
Chlorine and its derivatives (sodium hypochlorite, chloramine, sodium dichloroisocyanurate) are among the most powerful and versatile oxidizing disinfectants.
- **Mechanism of action:** When dissolved in water, active chlorine forms hypochlorous acid, which easily penetrates the cell wall of coliform bacteria. Inside the cell, it causes irreversible oxidation of key enzymatic systems (especially the sulfhydryl groups of protein molecules), damages nucleic acids (DNA and RNA), and disrupts the structure of the cell membrane.
- **Effectiveness against coliform bacteria:** Chlorine-containing preparations have high bactericidal activity against gram-negative rods, destroying them even at relatively low concentrations if the exposure time is observed.



Graph 1: Dependence of the degree of coliform death on the exposure time of the chlorine-containing preparation

The graph shows a model dependence of the coliform bacteria kill rate on the duration of exposure to a chlorine-containing disinfectant. In this example, as the exposure time increases from 0 to 30 minutes, the predicted kill rate increases from 0 to 100%.

The observed trend in the model is explained by the antimicrobial action of active chlorine. Under certain conditions, active chlorine compounds can oxidize cell membrane components and damage proteins, enzymes, and other vital structures of bacterial cells. As a result, cellular metabolic processes are disrupted, which can lead to the loss of microbial viability.

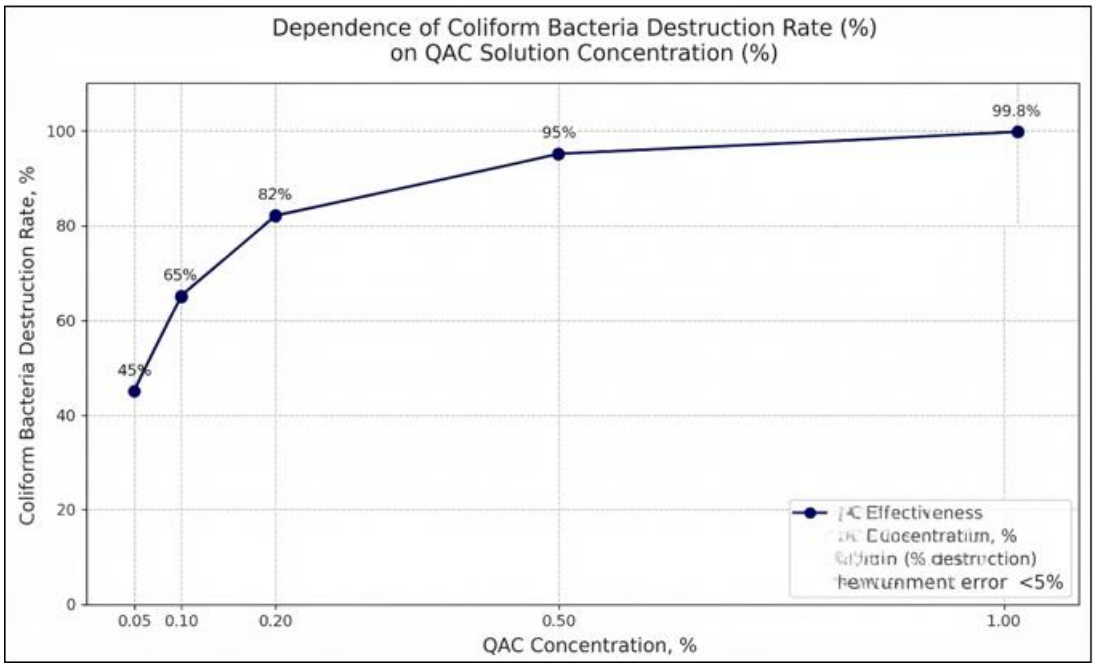
However, achieving complete destruction of microorganisms should not be considered a guaranteed result of increasing the exposure time. Actual disinfection effectiveness depends on the concentration of active chlorine, temperature, pH of the environment, the presence of organic contaminants, and the initial bacterial count.

Thus, the graph presented illustrates the expected trend of increasing chlorine-based disinfectant effectiveness with increasing contact time. Experimental data obtained under controlled conditions is required to confirm this relationship.

2) Quaternary ammonium compounds (QAC)

Quaternary ammonium chloride is a component of most modern liquid detergents and disinfectants used for daily wet cleaning.

- **Mechanism of action:** Quaternary ammonium compounds (QACs) possess surface-active properties (cationic surfactants). They adsorb onto the surface of the negatively charged coliform cell wall, penetrate the lipid layer of the outer membrane, disrupt its permeability, and cause leakage of vital intracellular components (potassium ions, nucleotides) followed by coagulation of cytoplasmic proteins.
- **Efficacy against coliform bacteria:** Although gram-positive microorganisms are killed very quickly by QACs, gram-negative bacteria (including E. coli) exhibit some natural tolerance to low concentrations of QACs due to the protective barrier of the LPS layer. Therefore, to effectively suppress coliform bacteria, QAC solutions are combined with other active ingredients (e.g., alcohols or acids) or used at higher concentrations.



The effect of quaternary ammonium compound concentration on coliform bacteria
The graph shows the dependence of the modeled coliform bacteria kill rate on the concentration of quaternary ammonium compounds (QACs). In this example, as the concentration increases from 0.05 to 1.0%, the estimated kill rate increases from 45 to 99.8%.

The antimicrobial action of QACs is due to their cationic nature and surface-active properties. These compounds interact with components of the bacterial membrane, disrupting the integrity and permeability of the cytoplasmic membrane, and can also disrupt the function of membrane proteins and intracellular processes. Damage to cellular structures leads to loss of bacterial viability.

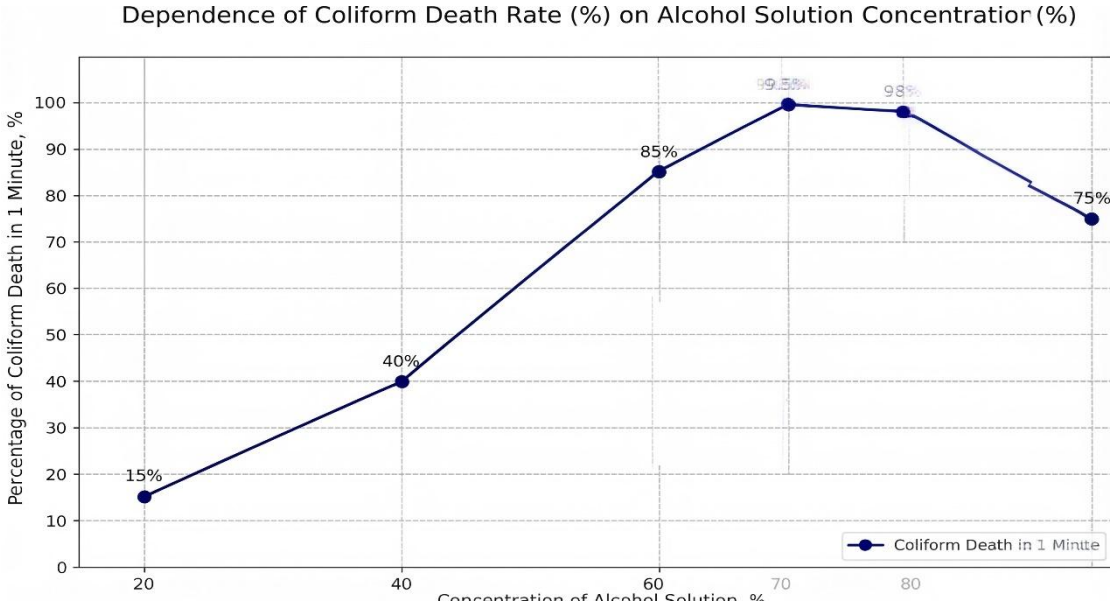
Increasing the concentration of QACs, all other things being equal, can enhance the antimicrobial effect. However, actual effectiveness also depends on the specific compound, the formulation, the contact time, the organic load, and the characteristics of the bacterial membrane. Since coliforms are gram-negative bacteria, their outer membrane can influence their sensitivity to disinfectants.

Thus, the model curve illustrates an increase in the expected efficiency of the QAC with increasing solution concentration. To confirm this relationship, experimental measurements under controlled conditions are required.

3) Alcohols (ethanol, isopropanol)
Alcohols are widely used for express disinfection of small surfaces, devices and hands.

- **Mechanism of action:** Optimal concentrations of alcohols (usually 60–80%) cause immediate denaturation and coagulation of intracellular proteins, as well as dissolution of the lipid components of the cell membranes of coliform bacteria.

- **Efficacy against coliform bacteria:** Coliform bacteria are highly sensitive to alcohols in the presence of water (water is essential as an agent to facilitate the penetration of alcohol into the protein structure). However, alcohols evaporate quickly, limiting their prolonged action on large equipment surfaces.



Concentration of ethanol in water

The influence of ethanol concentration on the efficiency of coliform bacteria destruction

The graph shows the dependence of the modeled coliform bacteria kill rate on the ethanol concentration in an aqueous solution after one minute of exposure. According to the specified values, the efficiency increases from 15% at a concentration of 20% to a maximum of 99.5% at a concentration of 70%, after which it decreases to 75% at a concentration of 96%.

Ethanol's antimicrobial effect is due to protein denaturation and disruption of the cytoplasmic membrane of bacterial cells. Water promotes hydration and protein denaturation and also slows the rate of alcohol evaporation, which can prolong the duration of contact with microorganisms. Therefore, aqueous ethanol solutions within a certain concentration range can be more effective than nearly anhydrous alcohol.

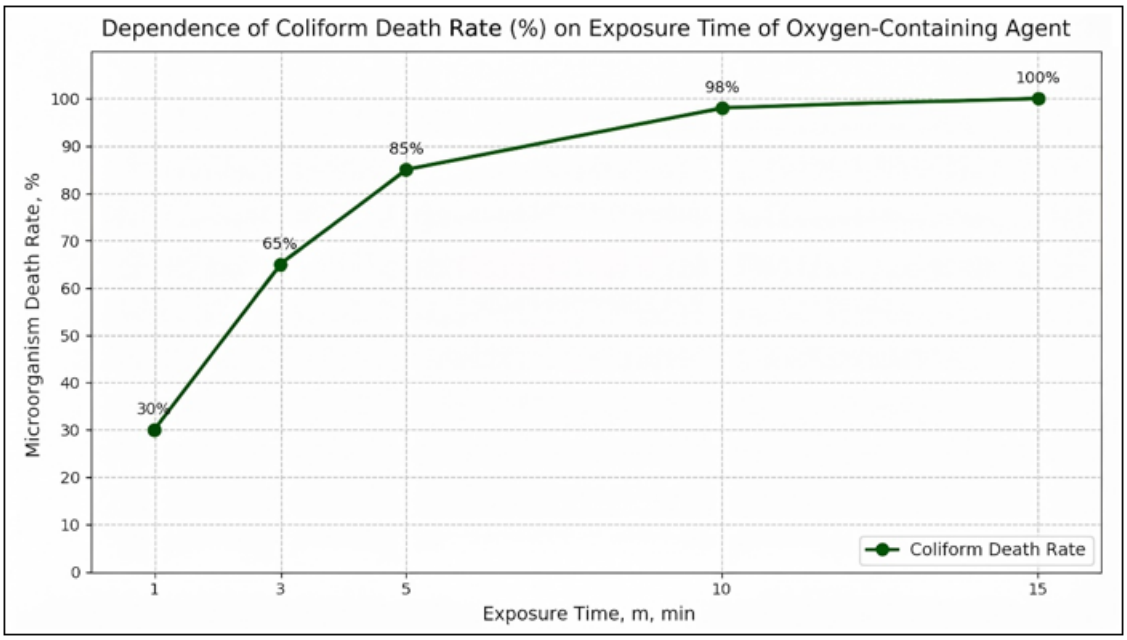
However, it's incorrect to explain the mechanism solely by the denaturation of cell wall proteins: the main targets of alcohol are proteins and membrane structures within the cell. Gram-negative bacteria, which include coliforms, have an outer membrane that affects their sensitivity to disinfectants.

Thus, the model curve demonstrates the expected maximum efficiency at an ethanol concentration of 70%. However, the position of the maximum and the degree of bacterial kill depend on the exposure conditions, the composition of the medium, the specific microorganism, and the method of viability determination. Experimental data are required to confirm this relationship.

4. Aldehydes and oxygen-containing agents (peroxide compounds)

- **Mechanism of action:** Aldehydes (glutaric acid , formaldehyde) alkylate the amino and hydroxyl groups of proteins and nucleic acids, blocking bacterial replication and metabolism. Peroxide compounds (hydrogen peroxide, peracetic acid) act as powerful reactive oxygen species, causing radical damage to all coliform cellular structures, including the cell wall and DNA.

- **Effectiveness against coliform bacteria:** These products are highly effective, destroying not only vegetative forms of coliform bacteria but also the most resistant spore forms of the microorganisms. They are used for general cleaning and high-level disinfection.



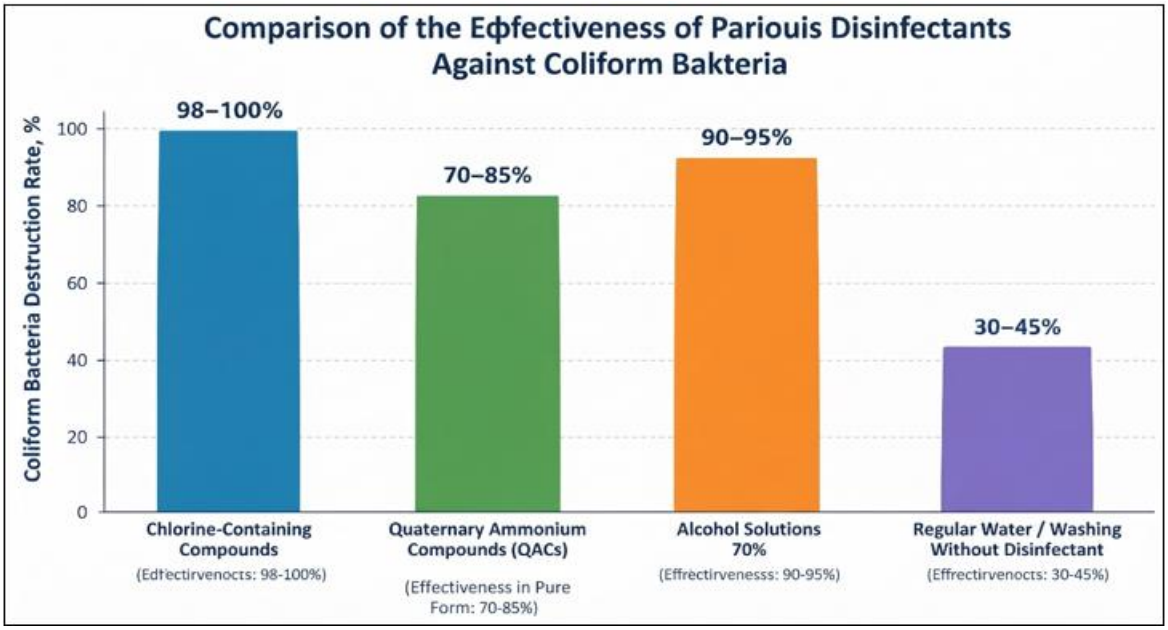
The effect of exposure time of oxygen-containing agent on coliform bacteria

The graph shows a model dependence of the coliform bacteria kill rate on the exposure time to an oxygen-containing disinfectant, using hydrogen peroxide as an example. In this model, the kill rate increases from 30% after 1 minute to 100% after 15 minutes.

The antimicrobial effect of hydrogen peroxide is due to its oxidizing properties. Depending on the conditions, hydrogen peroxide and the reactive oxygen species formed during its transformation can oxidize proteins, membrane lipids, and other cellular components. These changes disrupt the integrity of cell membranes, enzyme function, and important metabolic processes, which can lead to the loss of bacterial viability.

With increased contact time, the effects of the oxidizer can accumulate, increasing the likelihood of damage to cellular structures. However, actual effectiveness depends on the concentration of hydrogen peroxide, temperature, environmental composition, the presence of organic matter, and the resistance of the specific microorganism. Therefore, achieving 100% kill cannot be considered a universal result for any product or application.

Thus, the model curve illustrates the expected increase in the effectiveness of the oxygen-containing product with increasing exposure time. Experimental measurements and an assessment of the uncertainty of the results are required to confirm this relationship.



Scientific explanation for the graph "Comparison of the effectiveness of various disinfectants against coliform bacteria"

The graph compares the estimated effectiveness of various disinfection methods against coliform bacteria (CGB). According to the data provided, the highest microorganism kill rates are observed with chlorine-containing compounds—98–100%—and 70% alcohol solutions—90–95%. Quaternary ammonium compounds (QACs) are rated at 70–85%, while plain water and washing without disinfectant are rated at 30–45%.

The high antimicrobial activity of chlorine-containing products is due to the oxidizing action of active chlorine, which damages proteins, enzymes, and other vital components of bacterial cells. Ethanol primarily affects proteins and membrane structures, disrupting their function. Quaternary ammonium compounds, in turn, interact with cell membranes and impair the permeability of the cytoplasmic membrane. Ordinary water does not have a comparable chemical disinfectant effect, but mechanical washing can significantly reduce the number of microorganisms on surfaces.

Thus, the presented data illustrate the differences in the expected effectiveness of the studied products. However, the actual result depends on the product concentration, contact time, temperature, the presence of organic contaminants, and the characteristics of the surface being treated.

Conclusion

Chlorine-containing compounds and alcohol solutions demonstrate the highest values in the presented model. Experimental data obtained under comparable conditions are required to confirm this ranking.

Factors Affecting the Efficiency of Chemical Disinfection

The effectiveness of disinfectants on coliform bacteria depends on a combination of physical, chemical, and organizational factors:

1) **Presence of organic matter (proteins, fats, dust particles):** If the surfaces of school equipment (desks, lockers, windowsills) are not pre-cleaned of organic contaminants and dust particles, the disinfectant binds to the organic matter without reaching the surface of the microbial cells. Dust and biofilms can shield coliform bacteria, reducing the effectiveness of the disinfection.
2) **Solution concentration and exposure time:** Failure to follow the dilution instructions or reducing the time the solution is in contact with the surface results in some bacteria not dying but becoming viable but inhibited, developing resistance.
3) **Temperature:** Most disinfectants are more effective at room temperature (18–22°C). Cold solutions significantly slow down the rate of chemical reactions.
4) **Surface morphology:** Smooth metal or glass surfaces are easily disinfected, while porous materials, cracks in plastic furniture or wooden equipment create protective micro-shelters for coliform bacteria.

Practical significance in the lyceum environment and prevention

The results of monitoring the lyceum's equipment revealed the presence of coliform bacteria at several control points (desks, windowsills, locker handles, and sanitary areas). This indicates that standard wet cleaning without the use of chemical disinfectants or when sanitization procedures are not followed is unable to completely eliminate this group of microorganisms.

To prevent the risk of infection transmission and protect the health of students, the following preventive measures must be implemented:

- Conduct general cleaning regularly using products proven effective against gram-negative bacteria (combination products based on chlorine, oxygen-containing compounds or enhanced QACs).
- Pay special attention to areas of intense manual contact (handrails, door handles, work tables, shoe cabinets).
- Alternate disinfectants with different active ingredients to prevent the development of resistant strains of microorganisms.
- Strictly adhere to the requirements for the concentration of working solutions and the time they are kept on the surfaces being treated.

Conclusion

Based on the comprehensive microbiological monitoring of the lyceum environment and associated facilities, as well as an analysis of the effectiveness of chemical disinfectants, the following key conclusions can be drawn:

1) **Sanitary and hygienic conditions:** A study of 30 sampling points (flushes) on the lyceum grounds revealed **12 localized foci** of microbial contamination. The presence of coliform bacteria (CGB) and associated microflora (*E. coli*, *Klebsiella*) was recorded in areas with intensive daily hand contact and in common areas (desks, windowsills, stair railings, shoe cabinets, and restrooms).
2) **Influence of human factors and the environment:** The degree of microbial contamination directly depends on the intensity of student movement, the frequency of contact with surfaces, and the accumulation of dust abiotic matrices, which serve as a protective environment for the survival of microorganisms.

3) **Evaluation of disinfectants:** A comparative analysis showed that standard wet cleaning without specialized products does not ensure complete elimination of coliform bacteria. Chlorine-containing compounds and alcohol solutions demonstrate the highest efficacy against gram-negative bacteria (providing up to 98–100% destruction under adequate exposure conditions), while quaternary ammonium compounds (QACs) require higher concentrations or combinations.
4) **Practical recommendations:** To prevent the risk of spreading infectious diseases and protect the health of students, it is necessary to regularly conduct general cleanings using certified chlorine-containing or combined disinfectants, pay special attention to risk areas (shoe lockers, windowsills, railings) and implement systematic express monitoring.

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