Available online at
http://agrospheresmagazine.vitalbiotech.org/

ISSN (E): 2582 – 7022

Agrospheres:e- Newsletter, (2025) 6(7), 50-55

Article ID: 760

Why Depuration Matters: Purifying Bivalves for Safe Consumption

Krishan Kumar Yadav[1*], Sanjeev Sharma[1], Rishi Pal Yadav[1], Amit Singh Kshatri[1] Sneha Chaudhury[2], Pallavi Bhalavey[1]

[1]College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Haryana (125 004), India.
[2]College of Fisheries, Shirgaon, Ratnagiri (DBSKKV), Maharashtra-415629, India

*Corresponding Author
Krishan Kumar Yadav*

Article History
Received: 06.07.2025
Revised: 11.07.2025
Accepted: 16.07.2025

INTRODUCTION

What is Depuration?

Bivalve molluscs, such as mussels, clams, oysters, cockles, and scallops, are aquatic invertebrates characterized by a shell made up of two hinged valves. They are widely consumed across the world due to their “affordability, high-quality protein content, and health benefits, including omega-3 fatty acids and essential minerals” (Sami et al., 2024). Beyond their nutritional value, bivalves contribute to ecosystem services through biofiltration removing particulates, organic matter, nutrients, bacteria, and even some viruses from the water column (Rusco et al., 2024). This filtering capability, however, renders them susceptible to bioaccumulating waterborne contaminants such as pathogenic microorganisms, toxins, heavy metals (e.g., cadmium, mercury, lead), and chemical residues (Ibrahim and Abu El-Regal, 2014). These contaminants pose significant food safety hazards when bivalves are consumed, especially raw or lightly cooked. To address these risks, depuration is employed a post-harvest purification process in which live bivalves are transferred to tanks containing clean, disinfected water under controlled conditions for 24–72 hours. During this time, the natural filtering action of the bivalves helps expel faecal matter, sand, and microorganisms from their digestive tracts, reducing microbial contamination to levels safe for human consumption (de Souza et al., 2022). Depuration is considered a critical control point in the shellfish production chain and is legally mandated in many countries for molluscs harvested from Class B or conditionally approved waters.

Why is Depuration Important?

With the global population expected to rise to "9.8 billion by 2050 and 11.2 billion by 2100" (FAO, 2020), the pressure on global food systems to supply safe, sustainable protein sources is intensifying. Aquaculture has emerged as a key contributor to food security, accounting for nearly half of global fish production (FAO, 2020). However, bivalves' habitat in coastal zones, which are frequently impacted by untreated domestic sewage, agricultural runoff, industrial effluents, and tourism, increases the risk of contamination with "faecal bacteria (e.g., E. coli), viruses (e.g., norovirus, hepatitis A), and heavy metals" (Ofori, 2024). These contaminants may not only affect product quality but also result in foodborne illness outbreaks. Notably, norovirus is implicated in over 80% of viral outbreaks linked to shellfish consumption (Lee et al., 2008). Oysters are particularly vulnerable due to their tendency to bind viral particles to tissue glycans, which resist removal during standard depuration processes (Auger et al., 2023). While depuration is highly effective in reducing faecal bacterial levels, its performance is inconsistent or inadequate against viruses, biotoxins, and heavy metals (Guimarães Filho et al., 2022). Chemical disinfection agents like chlorine can impair bivalve filtration activity, cause off-flavours, and generate harmful by-products like trihalomethanes. Ozone, although bactericidal, can form carcinogenic bromates when applied to seawater (De Arruda, 2024).

The effectiveness of UV light depends heavily on water clarity and flow rate, limiting its use in large-scale depuration systems. This article reviews the principles, mechanisms, and technological advancements in bivalve depuration, emphasizing its critical role in food safety and sustainable aquaculture.

Principles and Process of Depuration

The Key Principles

Self-purification: Bivalves actively filter water through their gills and digestive systems. In clean seawater, they gradually eliminate accumulated pathogens and suspended solids (Fig. 1).

Controlled Environment: Depuration tanks maintain optimal temperature, salinity, oxygen, and water circulation, ensuring survival and active filtering by the bivalves.

Hygienic Handling: Bivalves are harvested from Class B or C areas, pre-cleaned, and handled hygienically to prevent recontamination during depuration.

Time and Efficiency: Effective depuration depends on sufficient residence time (often 24–72 hours), during which microbial reduction is monitored to meet regulatory standards.

Continuous Monitoring: Parameters such as microbial load, water quality, and Bivalves behaviour are regularly checked to ensure the system's efficacy.

Process of Depuration

Pre-Depuration Preparation: Bivalves are harvested from approved but non-purified (Class B or C) waters. They are cleaned of mud, debris, and fouling organisms using high-pressure water or brushing systems.

Loading into Depuration Tanks: Cleaned Bivalves are placed into sterile depuration tanks made of stainless steel, fiberglass, or food-grade plastic. Tanks are filled with filtered, UV-treated, or ozonated seawater mimicking natural habitat conditions.

Water Quality Control: Temperature: Typically maintained at 15–20°C, Salinity: Adjusted to match source environment (~25–35 ppt), Dissolved oxygen: Maintained >5 mg/L using aeration systems, Circulation: Continuous water flow ensures even exposure (Fig. 1).

Depuration Phase: Duration: Usually 24–72 hours, depending on the initial contamination level and species. Bivalves are kept submerged and undisturbed, allowing them to open and actively filter water. Filtration and disinfection systems continually clean the recirculating water.

Post-Depuration Testing: Random samples are taken to test microbial levels (e.g., E. coli using MPN or plate count methods). The Bivalves are released only if they meet safety standards as per local or international regulations (e.g., EU Regulation 853/2004, US FDA NSSP Guide).

Packaging and Distribution: Depurated bivalves are packaged hygienically, labelled with date and depuration details, and then sent for market distribution.

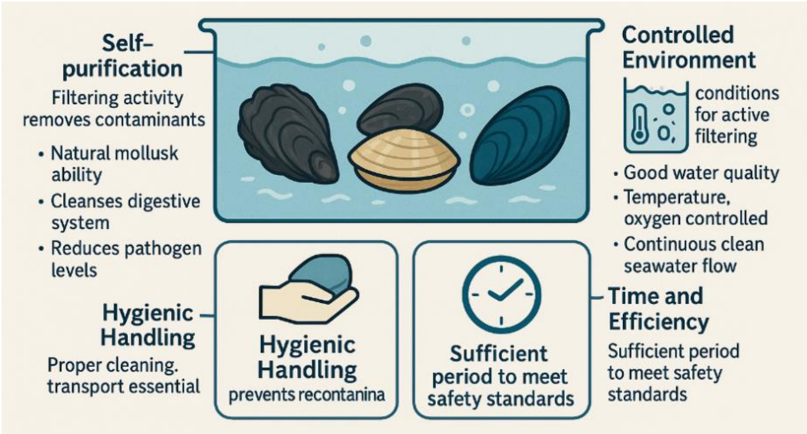

Fig. 1. Principles and process od bivalve's depuration

Methods of Depuration

Depuration is a critical post-harvest step to ensure the safety of bivalves for human consumption. Traditionally, this involves holding live bivalves in tanks filled with clean, disinfected seawater under controlled environmental conditions, allowing them to naturally purge microbial contaminants. While conventional depuration is effective in reducing bacterial loads, it often falls short in eliminating viruses, heavy metals, and chemical pollutants. To address these limitations, advanced and complementary depuration methods have been developed. Biological methods including the use of probiotics, bacteriocins, antimicrobial peptides, and bacteriophages leverage natural microbial interactions and host defence mechanisms to inhibit pathogens and enhance the immune response of bivalves. Physical methods such as ultraviolet (UV) irradiation, ozonation, high hydrostatic pressure (HHP), temperature control, and gamma irradiation target the physical destruction or inactivation of a wide range of pathogens and toxins (Martinez-Albores et al., 2020). Chemical methods, including the application of chelating agents like metallothioneins and biopolymers such as chitosan, facilitate the removal of heavy metals and biotoxins through binding and accelerated excretion (Fig. 2 & Table 1). Each method differs in its mechanism of action, efficacy, and suitability depending on the contaminant type and bivalve species (Table 1). Integrating these novel approaches with conventional depuration systems presents a promising strategy to enhance the microbiological and chemical safety, quality, and sustainability of bivalve aquaculture. Continued interdisciplinary research and industrial innovation are essential to optimize these technologies for commercial-scale application.

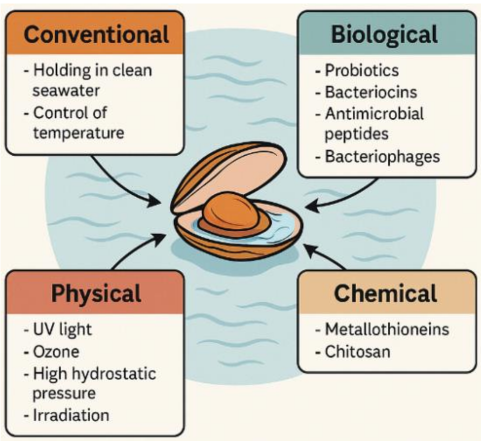

Fig. 2. Different type of depuration methods for bivalves

Table 1. Current trends and applications of bivalve depuration techniques: from traditional to advanced methods

Method Type	Specific Approach	Target Contaminants	Key Findings / Efficacy	Reference
Conventional Physical	UV Light	Bacteria, some viruses	Effective for bacteria; limited for viruses	Garcia et al., 2015
	Ozone	Bacteria, DSP toxins	Effective under specific conditions; possible toxic by-products	Martinez-Albores et al., 2020
	Temperature Modification	Bacteria, viruses	Increased temperature enhances depuration for some species	Martinez-Albores et al., 2020
Biological	Antimicrobial Peptides	*S. aureus*, *Salmonella*	In vitro activity; not applied in depuration yet	Ghorbanalizadeh et al., 2018
	Polysaccharides	Antibacterial, antiviral	Bioactive; used in medicine, not yet in depuration	Martinez-Albores et al., 2020
	Probiotics	*Vibrio*, *Listeria*, *E. coli*	Compete with pathogens, enhance immune response	Lee et al., 2010
	Bacteriocins	*L. monocytogenes*, *S. aureus*	Inhibit Gram-positive bacteria, yeast, and mold	Lee et al., 2010
	Bacteriophages	*E. coli*, *V. parahaemolyticus*	5–6 log CFU/g reduction within hours	Pereira et al., 2017
Chemical	Metallothioneins (MTs)	Cd^{2+}, Hg^{2+}, Zn^{2+}	25–50% reduction in heavy metals after 8–15 days	Zhang et al., 2017
	Chitosan	Heavy metals, PSP toxins	Up to 96.5% Hg^{2+} reduction; enhanced with ozone	Ningrum et al., 2016;
	Chitosan + Chlorella	PSP toxins	Up to 85% reduction in PSP toxins	Xie et al., 2013
Advanced Physical	High Hydrostatic Pressure (HHP)	*Vibrio spp.*, *Shigella*	3–4 log CFU/g reduction; non-viable shellfish	Martinez-Albores et al., 2020
	γ-Irradiation / X-ray	Biotoxins, *Vibrio spp.*	10–100% reduction of various toxins	Louppis et al., 2011
	Flash Freezing	*Vibrio spp.*	3.52 log MPN/g reduction	Martinez-Albores et al., 2020

Factors Affecting Depuration Efficiency

Depuration efficiency is influenced by biological, environmental, microbial, and operational factors. Optimizing each of these species selection, water parameters, system design, and treatment duration is key to achieving effective purification of bivalves (Table. 2).

Table 2. Factors Affecting Depuration Efficiency in Bivalves

Category	Factor	Effect on Depuration Efficiency
Bivalve-Related	Species	Different species have varied filtration capacities and pathogen retention abilities.
	Size and Age	Smaller and younger bivalves often depurate faster due to higher metabolic rates.
	Health Status	Healthy bivalves depurate more effectively; stress or disease impairs filtration and immunity.
Contaminant Factors	Type of Pathogen	Bacteria (e.g., *E. coli*) are easier to remove than viruses (e.g., norovirus) or

Category	Factor	Effect on Depuration Efficiency
		biotoxins.
	Initial Contamination Load	Higher loads reduce efficiency and require extended depuration times.
	Form of Contaminant	Particulate-bound contaminants are more easily eliminated than dissolved ones (e.g., heavy metals).
Water Quality	Temperature	Optimal range (18–22°C) enhances bivalve activity; extremes reduce depuration rate.
	Salinity	Species-specific optimal salinity (typically 25–32 ppt); deviations impair function.
	Dissolved Oxygen	High DO (>5 mg/L) supports bivalve respiration and filtration.
	pH	Ideal pH (7.5–8.5); acidic or alkaline water can stress bivalves.
	Turbidity	High turbidity clogs gills, decreasing filtration efficiency.
System-Related	Water Flow Rate	Maintains oxygen and removes excreted waste; stagnant water reduces efficiency.
	Tank Design & Stocking Density	Overcrowding leads to stress and reduced individual depuration efficiency.
	Disinfection Technologies	Use of UV, ozone, or filtration enhances removal of residual pathogens from the water.
	Duration of Depuration	Adequate time (24–72 hrs) is needed depending on bivalve species and contamination level.

CONCLUSION

Depuration provides a partial but promising solution to address heavy metal accumulation in bivalves. Its efficiency, however, varies depending on factors such as the type and level of heavy metal present, the duration and technique of depuration applied, species-specific physiological traits of the bivalves, and surrounding environmental conditions. To determine the most appropriate depuration strategy for a specific case, it is important to perform a detailed risk assessment along with a cost-benefit evaluation. Ongoing research is necessary to develop more reliable and targeted methods for controlling heavy metal contamination. Optimizing these key factors is essential to improve depuration outcomes and ensure that bivalve products are safe for human consumption.

REFERENCES

Auger, A., Yu, S. Y., Guu, S. Y., Quéméner, A., Euller-Nicolas, G., Ando, H., ... & Guerardel, Y. (2023). Species-specific N-glycomes and methylation patterns of oysters Crassostrea gigas and Ostrea edulis and their possible consequences for the Norovirus–HBGA interaction. *Marine drugs*, *21*(6), 342.

de Arruda Leme, E. J. (2024). *Manual prático de tratamento de águas residuárias*. EdUFSCar.

de Souza, R. V., Moresco, V., Miotto, M., Souza, D. S. M., Campos, C., & Suplicy, F. M. (2022). Depuration and heat treatment to reduce pathogen levels in bivalve molluscs produced in Santa Catarina State, Brazil. *Agropecuária Catarinense, Florianópolis*, *35*(2), 78-82.

Food and Agriculture Organization of the United Nations (FAO). (2020). The state of world fisheries and aquaculture. Sustainability in action: http://www.fao.org/state-of-fisheries-aquaculture.

Garcia, L. A., Nascimento, M. A., & Barardi, C. R. (2015). Effect of UV light on the inactivation of recombinant human adenovirus and murine norovirus seeded in seawater in shellfish depuration tanks. *Food and environmental virology*, *7*, 67-75.

Ghorbanalizadeh, A., Moshfegh, A., & Setorki, M. (2018). Evaluation of antimicrobial activity of peptides isolated from Cerastoderma and Didacta bivalves habitat in the southern shores of the Caspian Sea. *Sustainable Aquaculture* and Health Management Journal, 4(1), 1-12.

Guimarães Filho, C. E. D. F., Calixto, F. A. A., Kasnowski, M. C., & MESQUITA, E. D. F. M. D. (2022). Depuration of bivalve molluscs: a literature review. *Food Science and Technology*, *42*, e06622.

Ibrahim, N. K., & El-Regal, M. A. (2014). Heavy metals accumulation in marine edible molluscs, Timsah Lake, Suez Canal, Egypt. *ARPN Journal of Science and Technology*, *4*(4), 282-288.

Lee, R., Lovatelli, A., & Ababouch, L. (2008). *Bivalve depuration: fundamental and practical aspects* (No. 511, pp. 139-pp). Rome, Italy: Food and Agriculture Organization of the United Nations.

Louppis, A. P., Katikou, P., Georgantelis, D., Badeka, A. V., & Kontominas, M. G. (2011). Effect of ozonation and γ-irradiation on post-harvest decontamination of mussels (Mytillus galloprovincialis) containing diarrhetic shellfish toxins. *Food Additives & Contaminants: Part A*, *28*(12), 1735-1744.

Martinez-Albores, A., Lopez-Santamarina, A., Rodriguez, J. A., Ibarra, I. S., Mondragón, A. D. C., Miranda, J. M., ... & Cepeda, A. (2020). Complementary methods to improve the depuration of bivalves: A review. *Foods*, *9*(2), 129.

Ningrum, E. W., Solihin, D. D., & Butet, N. A. (2016). Mercury depuration effectiveness on green mussel (Perna viridis L.) and blood cockle (Anadara granosa L.) from Jakarta Bay using ozone, chitosan and hydrodynamic technique. In *IOP Conference Series: Earth and Environmental Science* (Vol. 31, No. 1, p. 012041). IOP Publishing.

Ofori, K. F. (2024). *Investigation of the Presence of Bacteria in Seawater and Oysters From Sally Cove in Rehoboth Bay, Delaware* (Master's thesis, Delaware State University).

Pereira, C., Moreirinha, C., Teles, L., Rocha, R. J., Calado, R., Romalde, J. L., ... & Almeida, A. (2017). Application of phage therapy during bivalve depuration improves Escherichia coli decontamination. *Food microbiology*, *61*, 102-112.

Rusco, G., Roncarati, A., Di Iorio, M., Cariglia, M., Longo, C., & Iaffaldano, N. (2024). Can IMTA System improve the productivity and quality traits of aquatic organisms produced at different trophic levels? The benefits of IMTA—Not only for the ecosystem. *Biology*, *13*(11), 946.

Sami, M. (2024). Depuration of heavy metals in bivalves: A review. *Egyptian Journal of Aquatic Biology and Fisheries*, *28*(4), 1823-1834.

Xie WanCui, X. W., Liu XiaoLi, L. X., Yang XiHong, Y. X., Zhang ChaoHua, Z. C., & Bian ZhongYuan, B. Z. (2013). Accumulation and depuration of paralytic shellfish poisoning toxins in the oyster Ostrea rivularis Gould-chitosan facilitates the toxin depuration.

Zhang, B., Fang, C. D., Xu, J. H., & Cao, H. J. (2017). Depuration of cadmium from blue mussel (Mytilus edulis) by protein hydrolysate–Fe2+ complex: the role of metallothionein. *Journal of food science*, *82*(11), 2767-2773