Application of Nanochitosan in Fish Detoxification/Nano-Based Depuration

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Nanochitosan-Based Enhancement of Fisheries and Aquaculture

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Abstract

The chapter explores the application of nanochitosan in detoxification and depuration of captive fish towards attainment of Sustainable Development Goal 14. The application of nanochitosan in fish detoxification, often referred to as nano-based depuration, represents a cutting-edge and sustainable

approach to addressing the challenges posed by environmental contaminants in aquaculture. This innovative method harnesses the unique properties of nanochitosan, a nanoscale derivative of chitosan, to capture, immobilize, and gradually release contaminants in aquatic environments. Nanochitosan-based fish detoxification or nano-depuration represents a forward-looking approach to ensuring the safety and sustainability of aquaculture practices. This method leverages nanochitosan's unique properties, such as adsorption capacity and controlled release, to reduce the bioavailability of contaminants, protect fish health, and enhance the quality of seafood products. It aligns with the principles of environmental responsibility and offers the flexibility to address diverse contaminant profiles, making it a promising tool in the field of aquaculture and environmental management.

References

- Abd-Elhakeem, M. A., Ramadan, M. M., & Basaad, F. S. (2016). Removing of heavy metals from water by chitosan nanoparticles. *Journal of advances in Chemistry, 11*(7), 3765–3771. https://doi.org/10.24297/jac.v11i7.2200

  Article **Google Scholar**

- Benettayeb, A., Seihoub, F. Z., Pal, P., Ghosh, S., Usman, M., Chia, C. H., Usman, M., & Sillanpää, M. (2023). Chitosan nanoparticles as potential nano-sorbent for removal of toxic environmental pollutants. *Nanomaterials, 13*(3), 447. https://doi.org/10.3390/nano13030447

  Article **CAS** **PubMed** **PubMed Central** **Google Scholar**

- Chauhan, D., Jaiswal, M., & Sankararamakrishnan, N. (2012). Removal of cadmium and hexavalent chromium from electroplating waste water using thiocarbamoyl chitosan. *Carbohydrate Polymers, 88*(2), 670–675. https://doi.org/10.1016/j.carbpol.2012.01.014

  Article **CAS** **Google Scholar**

- Chen, L. F., Liang, H. W., Lu, Y., Cui, C. H., & Yu, S. H. (2011). Synthesis of an attapulgite clay@carbon nanocomposite adsorbent by a hydrothermal carbonization process and their application in the removal of toxic metal ions from water. *Langmuir, 27*(14), 8998–9004. https://doi.org/10.1021/la2017165

Article CAS PubMed Google Scholar

- Cheung, R. C. F., Ng, T. B., Wong, J. H., & Chan, W. Y. (2015). Chitosan: An update on potential biomedical and pharmaceutical applications. *Marine Drugs, 13*, 5156–5186. https://doi.org/10.3390/md13085156

  Article CAS PubMed PubMed Central Google Scholar

- Chiou, M. S., & Li, H. Y. (2003). Adsorption behavior of reactive dye in aqueous solution on chemical cross-linked chitosan beads. *Chemosphere, 50*(8), 1095–1105. https://doi.org/10.1016/S0045-6535(02)00636-7

  Article CAS PubMed Google Scholar

- Divya, K., & Jisha, M. S. (2018). Chitosan nanoparticles preparation and applications. *Environmental Chemistry Letters, 16*, 101–112. https://doi.org/10.1007/s10311-017-0670-y

  Article CAS Google Scholar

- Dutta, P. K., Dutta, J., & Tripathi, V. S. (2004). Chitin and chitosan: Chemistry, property and application. *Journal of Scientific and Industrial Research, 63*, 20–31.

  CAS Google Scholar

- Eliaz, I., Weil, E., & Wilk, B. (2006). Integrative medicine and the role of modified citrus pectin/alginates in heavy metal chelation and detoxification-five case reports. *Forschende Komplementärmedizin, 14*(6), 358–364. https://doi.org/10.1159/000109829

  Article Google Scholar

- El-Naggar, M. M., Abou-Elmagd, W. S. I., Suloma, A. M., El-Shabaka, H. A., Khalil, M. T., & Abd El-Rahman, F. A. A. (2019). Optimization and physicochemical characterization of chitosan and chitosan nanoparticles extracted from the crayfish *Procambarus clarkii* wastes. *Journal of Shellfish Research, 38*(2), 385–395. https://doi.org/10.2983/035.038.0220

Article Google Scholar

- El-Naggar, M. M., Haneen, D. S. A., Mehany, A. B. M., & Khalil, M. T. (2020). New synthetic chitosan hybrids bearing some heterocyclic moieties with potential activity as anticancer and apoptosis inducers. *International Journal of Biological Macromolecules, 150*, 1323–1330. https://doi.org/10.1016/j.ijbiomac.2019.10.142

  Article CAS PubMed Google Scholar

- El-Naggar, M. M., Salah, S., El-Shabaka, H. A., Abd El-Rahman, F. A. A., Khalil, M. T., & Suloma, A. (2021). Efficacy of dietary chitosan and chitosan nanoparticles supplementation on health status of Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture Reports, 19*, 100628. https://doi.org/10.1016/j.aqrep.2021.100628

  Article Google Scholar

- El-Naggar, M. M., Medhat, F., & Taha, A. (2022a). Applications of chitosan and chitosan nanoparticles in fish aquaculture. *Egyptian Journal Of Aquatic Biology And Fisheries, 26*(1), 23–43. https://doi.org/10.21608/ejabf.2022.213365

  Article Google Scholar

- El-Naggar, M. M., Salaah, S., Suloma, S., Khalil, M. T., & Emam, W. W. M. (2022b). Impact of chitosan and chitosan nanoparticles on reducing heavy metals in the Nile tilapia, *Oreochromis niloticus*. *Egyptian Journal of Aquatic Biology & Fisheries Zoology Department, Faculty of Science, Ain Shams University, Cairo, Egypt., 26*(2), 859–875.

  Google Scholar

- El-Sayed, A.-F. M. (2019). *Tilapia culture*. Academic. https://doi.org/10.1016/C2017-0-04085-5

  Book Google Scholar

- Fadlaoui, S., El Asri, O., Mohammed, L., Sihame, A., Omari, A., & Melhaoui, M. (2019). Isolation and characterization of chitin from shells of the freshwater crab potamon algeriense. *Progress on Chemistry and Application of Chitin and its Derivatives, XXIV*, 23–35. https://doi.org/10.15259/PCACD.24.002

Article **Google Scholar**

- Fu, F., & Wang, Q. (2011). Removal of heavy metal ions from wastewaters: A review. *Journal of Environmental Management, 92*(3), 407–418. https://doi.org/10.1016/j.jenvman.2010.11.011

  Article **CAS** **PubMed** **Google Scholar**

- Gamage, A., & Shahidi, F. (2007). Use of chitosan for the removal of metal ion contaminants and proteins from water. *Food Chemistry, 104*(3), 989–996. https://doi.org/10.1016/j.foodchem.2007.01.004

  Article **CAS** **Google Scholar**

- Goff, J. P. (2018). Invited review: Mineral absorption mechanisms, mineral interactions that affect acid-base and antioxidant status, and diet considerations to improve mineral status. *Journal of Dairy Science, 101*(4), 2763–2813. https://doi.org/10.3168/jds.2017-13112

  Article **CAS** **PubMed** **Google Scholar**

- Guibal, E. (2004). Interactions of metal ions with chitosan-based sorbents: A review. *Separation and Purification Technology, 38*(1), 43–74. https://doi.org/10.1016/j.seppur.2003.10.004

  Article **CAS** **Google Scholar**

- Hussein, M. H. M., El-Hady, M. F., Sayed, W. M., & Hefni, H. (2012). Preparation of some chitosan heavy metal complexes and study its properties. *Polymer Science, Series A, 54*(2), 113–124. https://doi.org/10.1134/S0965545X12020046

  Article **CAS** **Google Scholar**

- Kaleem, O., & Sabi, A.-F. B. S. (2021). Overview of aquaculture systems in Egypt and Nigeria, prospects, potentials, and constraints. *Aquaculture and Fisheries, 6*(6), 535–547. https://doi.org/10.1016/j.aaf.2020.07.017

  Article **Google Scholar**

- Marwa, M. E., Sally, S., Ashraf, S., Magdy, T. K., & Wiame, W. M. E. (2022). Impact of chitosan and chitosan nanoparticles on reducing heavy metals in the Nile tilapia, *Oreochromis niloticus*. *Egyptian Journal* *of Aquatic Biology & Fisheries Zoology. Department, Faculty of Science, Ain Shams University, Cairo, Egypt, 26*(2), 859–875. ISSN 1110–6131.

Google Scholar

- Mohanasrinivasan, V., Mishra, M., Paliwal, J. S., Singh, S. K., Selvarajan, E., Suganthi, V., & Devi, C. S. (2014). Studies on heavy metal removal efficiency and antibacterial activity of chitosan prepared from shrimp shell waste. *3 Biotech, 4*, 167–175.

  Article CAS PubMed Google Scholar

- Nalini, S., Ajit, K. S., & Rashmi, S. (2007). Novel chitosan derivative for the removal of cadmium in the presence of cyanide from electroplating wastewater. *Journal of Hazardous Materials, 148*(1–2), 353–359.

  Google Scholar

- Salaah, S. M., El-Gaar, D. M., & Gaber, H. S. (2021). Potential effects of dietary chitosan against lead-induced innate immunotoxicity and oxidative stress in Nile tilapia (*Oreochromis niloticus*). *The Egyptian Journal of Aquatic Research, 48*(2), 123–129. https://doi.org/10.1016/j.ejar.2021.10.004

  Article Google Scholar

- Setiyorini, Y., Anggraeni, A., & Pintowantoro, S. (2022). In-vivo study of nano chitosan as therapeutic agent for toxic metal implant. *Results in Engineering, 13*, 100352. https://doi.org/10.1016/j.rineng.2022.100352

  Article CAS Google Scholar

- Seyedmohammadi, J., Motavassel, M., Maddahi, M. H., & Nikmanesh, S. (2016). Application of nanochitosan and chitosan particles for adsorption of Zn(II) ions pollutant from aqueous solution to protect environment. *Modelling Earth Systems and Environment, 2*, 165. https://doi.org/10.1007/s40808-016-0219-2

  Article Google Scholar

- Shekhawat, A., Kahu, S., Saravanan, D., & Jugade, R. (2022). Bi-functionalized Ionic Liquid-Thiourea Chitosan for effective decontamination of Cd(II) and Hg(II) from water bodies. *Current Research in Green and Sustainable Chemistry, 5*, 100246.

Article CAS Google Scholar

- Sun, S., Wang, L., & Wang, A. (2006). Adsorption properties of crosslinked carboxymethyl-chitosan resin with Pb(II) as template ions. *Journal of Hazardous Materials, 136*(2006), 930–937.

  Article CAS PubMed Google Scholar

- Thilagar, G., & Samuthirapandian, R. (2020). Chitosan from crustacean shell waste and its protective role against lead toxicity in *Oreochromis mossambicus*. *Toxicology Reports, 7*, 296–303. https://doi.org/10.1016/j.toxrep.2020.02.006

  Article CAS PubMed PubMed Central Google Scholar

- Wan Ngah, W. S. W., & Fatinathan, S. (2010). Pb (II) biosorption using chitosan and chitosan derivatives beads: Equilibrium, ion exchange and mechanism studies. *Journal of Environmental Sciences, 22*(3), 338–346. https://doi.org/10.1016/S1001-0742(09)60113-3

  Article CAS Google Scholar

- Wang, S. H., & Chen, J. C. (2005). The protective effect of chitin and chitosan against *Vibrio alginolyticus* in white shrimp *Litopenaeus vannamei*. *Fish & Shellfish Immunology, 19*(2005), 191–204. https://doi.org/10.1016/j.fsi.2004.11.003

  Article CAS Google Scholar

- Wang, Y., & Li, J. (2011). Effects of chitosan nanoparticles on survival, growth, and meat quality of tilapia, *Oreochromis nilotica*. *Nanotoxicology, 5*(3), 425–431. https://doi.org/10.3109/17435390.2010.530354

  Article CAS PubMed Google Scholar

- Wassmur, B. (2012). *Detoxification mechanisms in fish – Regulation and function of biotransformation and efflux in fish exposed to pharmaceuticals and other pollutants* (pp. 66). ISBN 978-91-628-8540-3. http://hdl.handle.net/2077/30452

- Yu, K., Ho, J., Mccandlish, E., Buckley, B., Patel, R., Li, Z., & Shapley, N. C. (2013). Copper ion adsorption by chitosan nanoparticles and alginate microparticles for water purification applications. *Colloids and*

Surfaces A: Physicochemical and Engineering Aspects, 425, 31–41. https://doi.org/10.1016/j.colsurfa.2012.12.043

Article CAS Google Scholar

- Zaki, M. A., Salem, M. E. S., Gaber, M. M., & Nour, A. M. (2015). Effect of chitosan supplemented diet on survival, growth, feed utilization, body composition & histology of sea bass (*Dicentrarchus labrax*) world. *Journal of Engineering Technology, 3*(2015), 38–47.

  Google Scholar

- Zareie, C., Eshkalak, S. K., Darzi, G. N., Baei, M. S., Younesi, H., & Ramakrishna, S. (2019). Uptake of Pb (II) ions from simulated aqueous solution via nanochitosan. *Coatings, 9*(12), 862. https://doi.org/10.3390/coatings9120862

  Article CAS Google Scholar

- Zhao, D., Yu, S., Sun, B., Gao, S., Guo, S., & Zhao, K. (2018). Biomedical applications of chitosan and its derivative nanoparticles. *Polymers, 10*(4), 462–479. https://doi.org/10.3390/polym10040462

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