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How safe are gold nanoparticles? A case study in marine organisms

Chaired by **Dr. Alfredo Berzal-Herranz** and **Prof. Dr. Maria Emília Sousa**

pharmaceuticals MDPI

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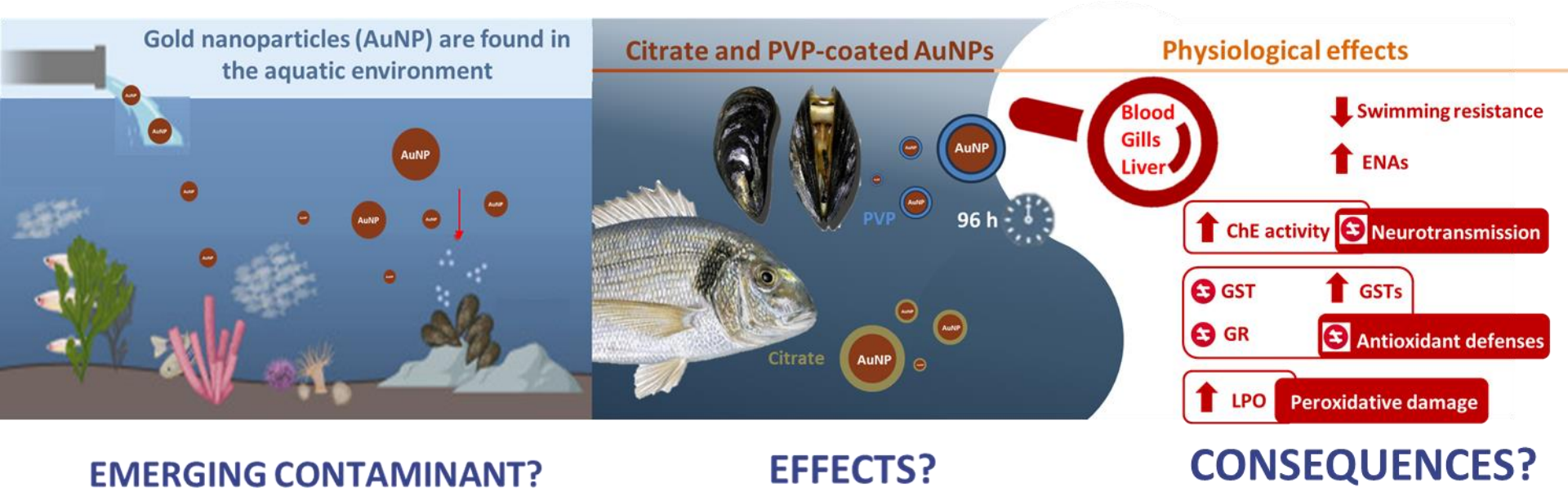
How safe are gold nanoparticles? A case study in marine organisms

Graphical Abstract



Abstract: Gold nanoparticles have been widely used in several areas of human activities, including the biomedical field, due to their small size and unique properties. However, its entrance into the environment may be expected with their increased use. There is thus the need to understand how these nanoparticles used in biomedical applications will affect environmental health, and therefore human health. One of the requirements for using gold nanoparticles is their non-toxic and biocompatible nature to both in vivo and in vitro systems. Some concerns on their possible impact in the environment have been raised with few studies addressing the effects of the particles in marine organisms. This work will present data on the biochemical effects of gold nanoparticles in marine organisms (bivalves and fish), alone and combined with other environmental contaminants. Overall, data show that the particle stability in high ionic strength media and the observed effects are highly dependent on the surface coating. Nonetheless, the studied nanoparticles proved able to induce peroxidative damage both in bivalves and fish, and to promote alterations in neurotransmission. Although the benefits of these nanomaterials are extensively shown, their unintentional release or disposal deserves more care and precaution.

Keywords: Biochemical effects; Gold nanoparticles; Impact; Marine organisms.

Introduction: Gold nanoparticles (AuNPs)

Gold nanoparticles (AuNPs)

BIOMEDICAL FIELD

Characteristics such as:

- ✓ **High chemical stability;**
- ✓ **Unique optical features;**
- ✓ **Biological compatibility;**
- ✓ **Controllable morphology;**
- ✓ **Size dispersion;**
- ✓ **Easy surface functionalization.**

Multiple applications

- Molecular diagnostics
- Cancer diagnostics
- Bioimaging
- Targeted drug and gene-delivery systems
- Therapeutics
- Microbicides

Milan et al., 2022 - https://doi.org/10.3390/ma15093355
Hu et al., 2020 - https://doi.org/10.3389/fbioe.2020.00990

Introduction: Gold nanoparticles (AuNPs)

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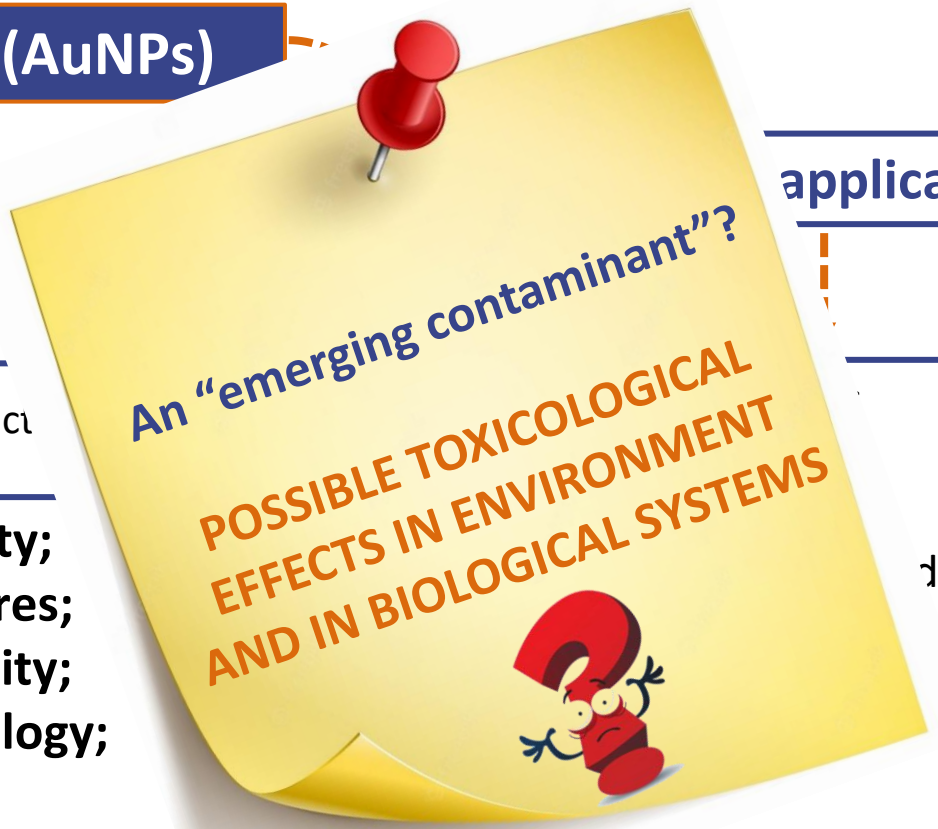
applications

delivery systems



Milan et al., 2022 - https://doi.org/10.3390/ma15093355
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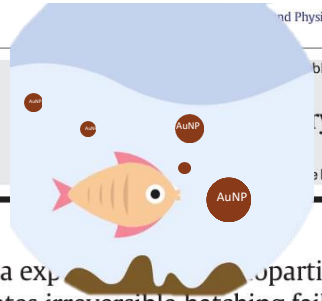
Introduction: Are gold nanoparticles safe?



Japanese medaka exp… …oparticles: Only embryonic exposure generates irreversible hatching failure, developmental failure, and mortality of sac-fry

SAFE?

Yu-Jin Shin [1], Sun-Hwa Nam [1], Youn-Joo An *
Department of Environmental Science, Konkuk University, 1 Hwayang-dong, Gwangjin-gu, Seoul 143-701, Republic of Korea

OR

UNSAFE?

Effects of silver and gold nanoparticles on rainbow trout (*Oncorhynchus mykiss*) hepatocytes

Julia Farkas [a,b,*], Paul Christian [c], Julián Alberto Gallego Urrea [d], Norbert Roos [e], Martin Hassellöv [d], Knut Erik Tollefsen [a], Kevin V. Thomas [a]

Assessment of gold nanoparticle effects in a marine teleost (*Sparus aurata*) using molecular and biochemical biomarkers

M. Teles [a,*], C. Fierro-Castro [a], P. Na-Phatthalung [b], A. Tvarijonaviciute [c], T. Trindade [e], A.M.V.M. Soares [d], L. Tort [a], M. Oliveira [d]

Introduction: What was tested in this study?

This work will present data on the biochemical effects of gold nanoparticles in *Sparus aurata* (fish) and *Mytilus galloprovincialis* (bivalve), with two surface coatings (citrate or PVP).

7 nm GNPs

Prepared by citric acid reduction of gold (III) chloride (Shiba, 2013) – **cGNPs**

Part of the synthesized citrate coated gold nanoparticles (cGNPs) were coated with PVP (Barreto et al., 2015) – **P GNPs**

Sparus aurata
Juvenile 9 + 0.9 cm

Artificial seawater – 35% Salinity
Water renewal – every 24h
Temperature – 20ºC

Mytilus galloprovincialis
5.1 + 0.4 cm

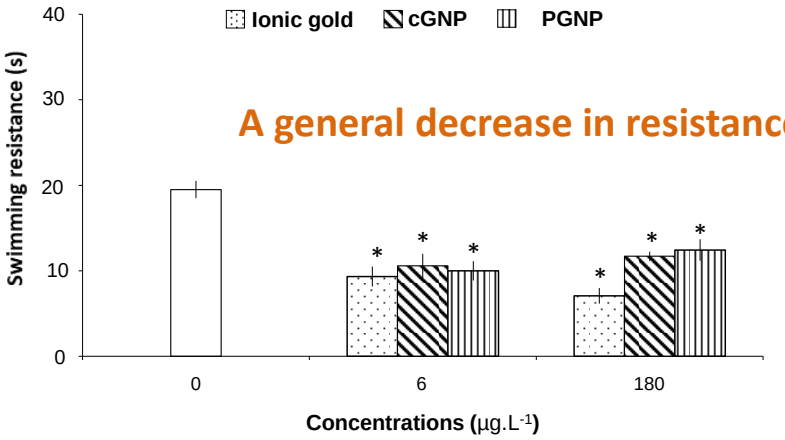
PARAMETERS ANALYZED

- Swimming resistance;
- Erythrocytes nuclear abnormalities;
- Acetylcholinesterase enzymes;
- Enzymes involved in biotransformation;
- Enzymes involved in antioxidant defenses.

Results and Discussion: Effects of ionic gold, cGNP and P GNP

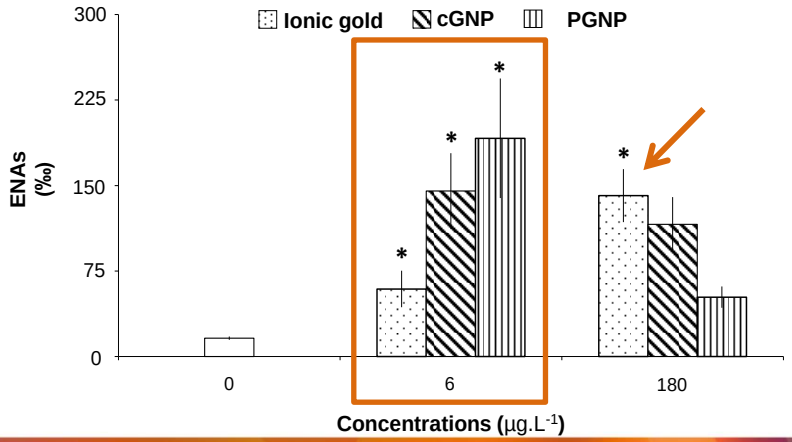
In *S. aurata*

Swimming resistance

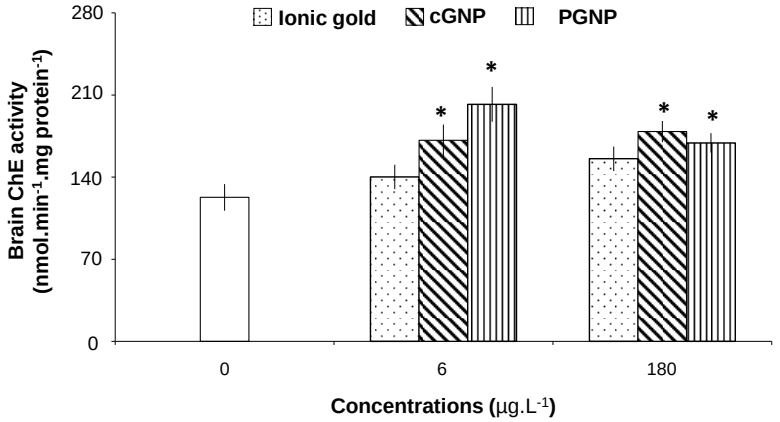


A general decrease in resistance time

Erythrocytes nuclear abnormalities (ENAs)



Changes in Neurotransmission

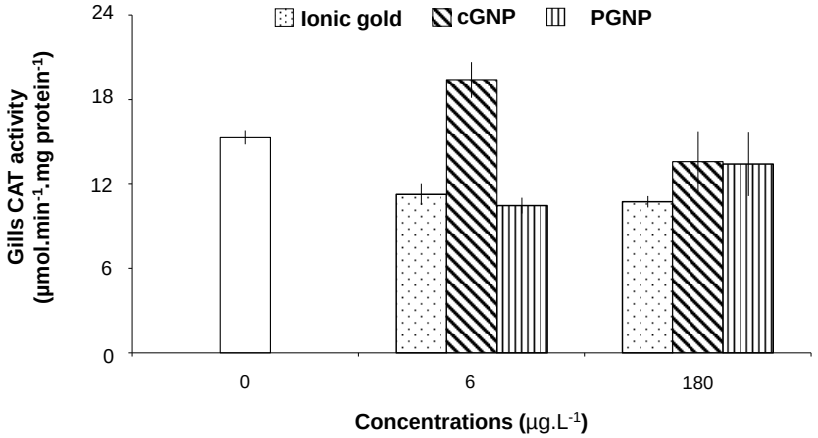


Significantly higher ChE activity

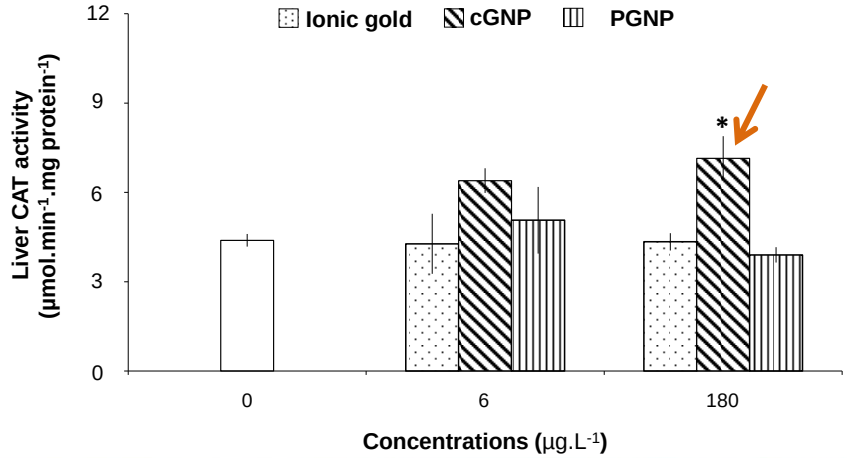
Results and Discussion: Effects of ionic gold, cGNP and P GNP

Gills catalase activity

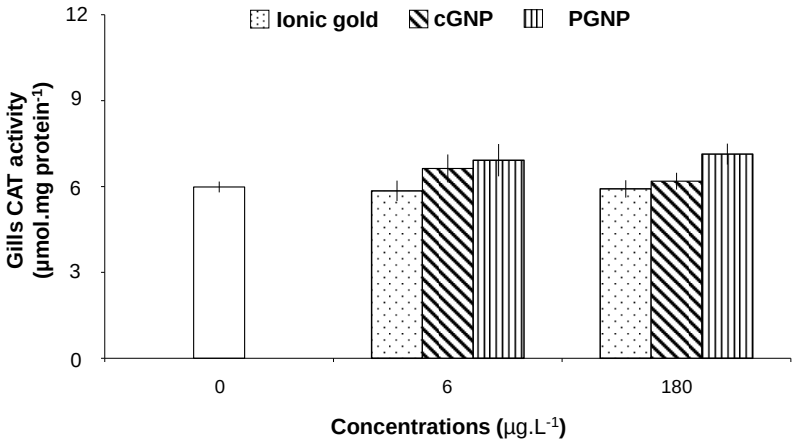
In *S. aurata* gills and liver



Liver catalase activity



In *M. galloprovincialis* gills

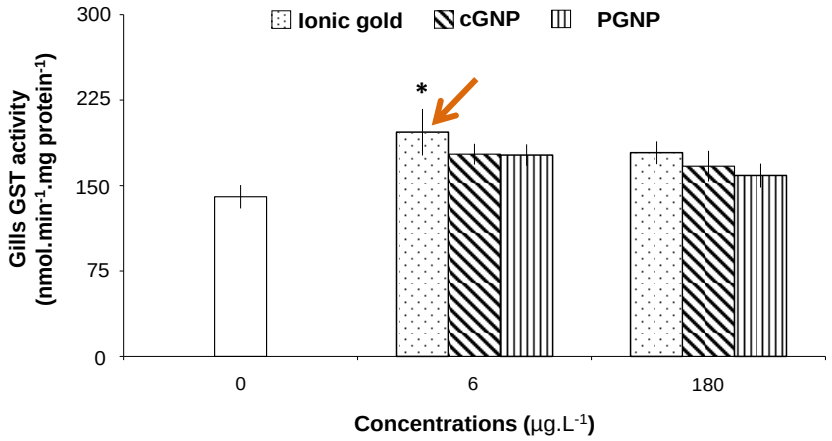


cGNPs induced an increase of catalase activity in *S.aurata* liver

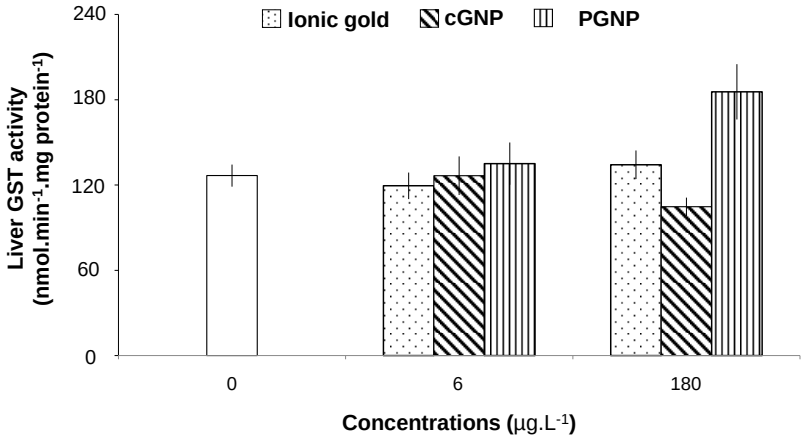
Results and Discussion: Effects of ionic gold, cGNP and P GNP

In *S. aurata* gills and liver

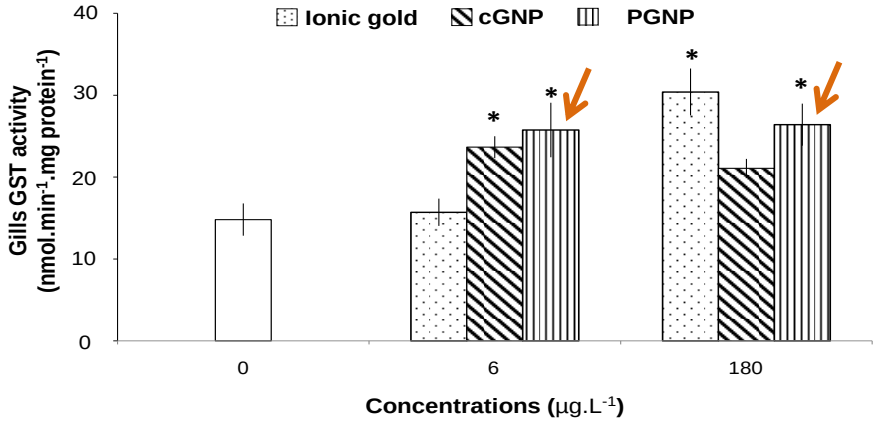
Gills GSTs levels



Liver GSTs levels



In *M. galloprovincialis* gills



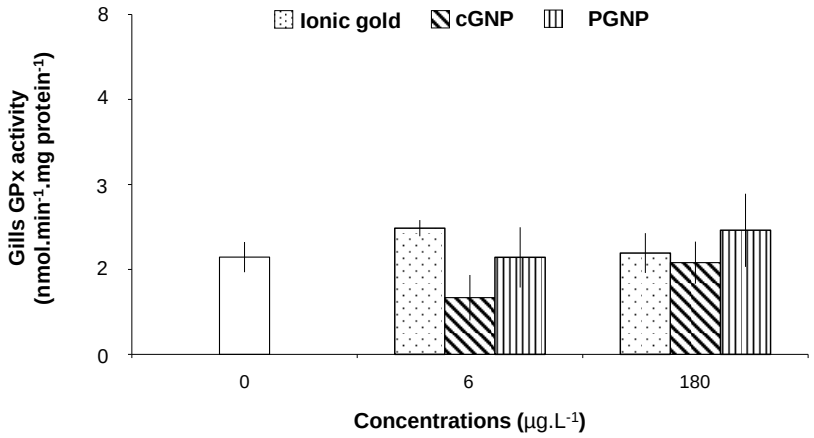
Levels of GSTs, enzymes involved in phase II of biotransformation and antioxidant defenses, are significantly altered

GSTs, Glutathione S-Transferases

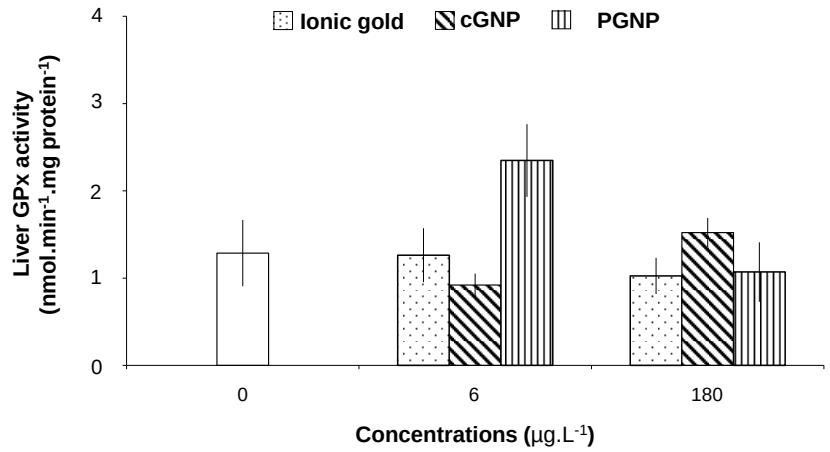
Results and Discussion: Effects of ionic gold, cGNP and P GNP

In *S. aurata* gills and liver

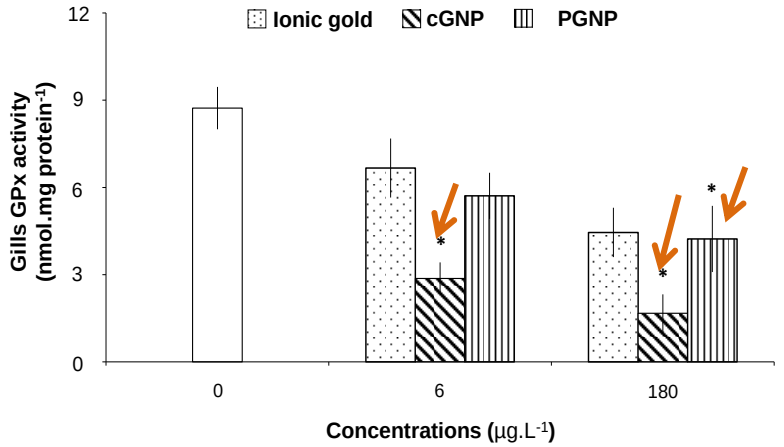
Gills GPx activity



Liver GPx activity



In *M. galloprovincialis* gills



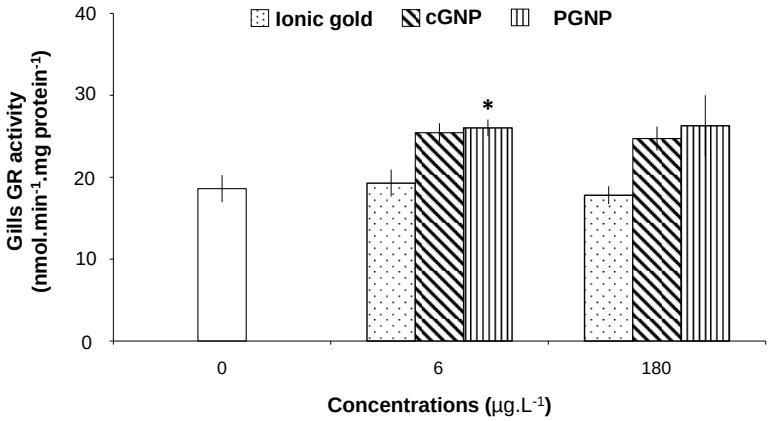
Inhibitory effect on the antioxidant enzyme glutathione peroxidase in *M. galloprovincialis* gills

GPx, Glutathione peroxidase

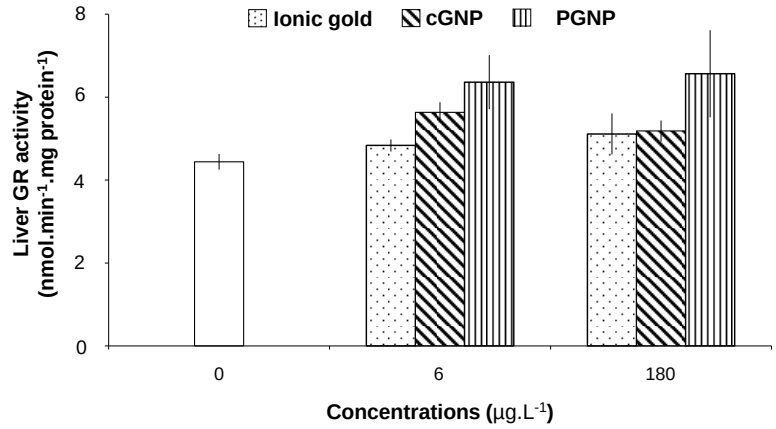
Results and Discussion: Effects of ionic gold, cGNP and P GNP

In *S. aurata* gills and liver

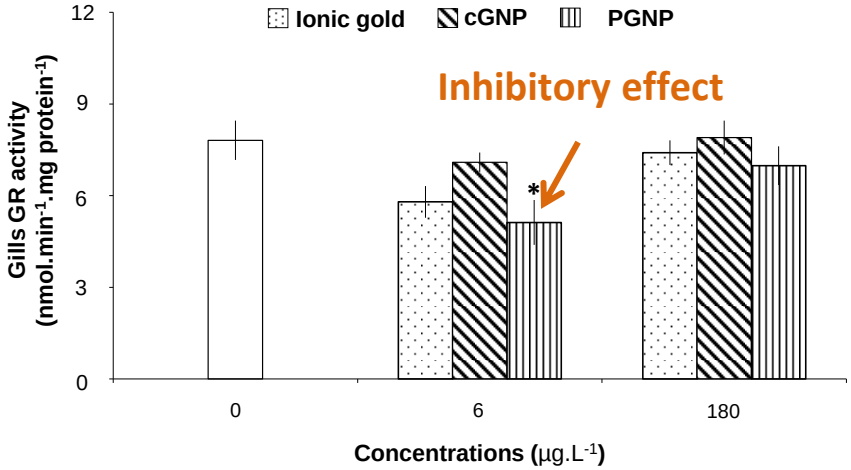
Gills GR activity



Liver GR activity



In *M. galloprovincialis* gills



Levels of GR, an important enzyme involved in the reduction of oxidized glutathione to reduced glutathione, are significantly altered

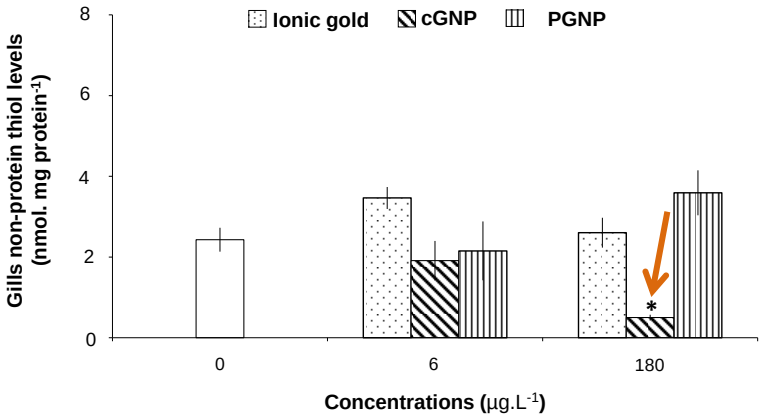
GR, Glutathione reductase

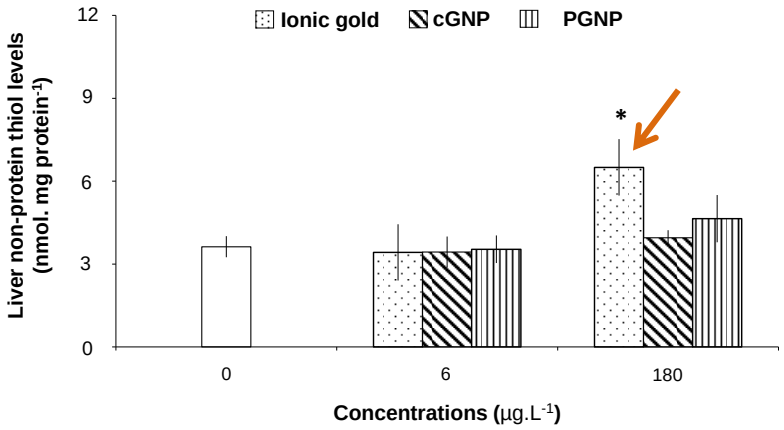
Results and Discussion: Effects of ionic gold, cGNP and P GNP

Gills non-protein thiols

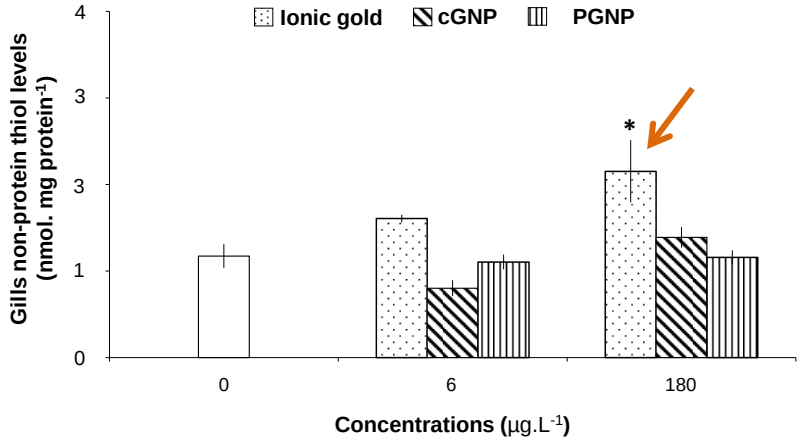
Liver non-protein thiols

In *S. aurata* gills and liver





In *M. galloprovincialis* gills



Different effects of the gold nanoparticles

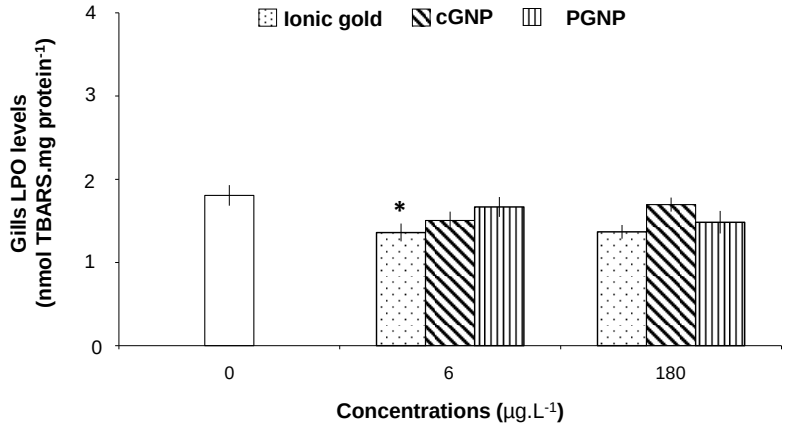
Deflection in the antioxidant levels in both species

Results and Discussion: Effects of ionic gold, cGNP and P GNP

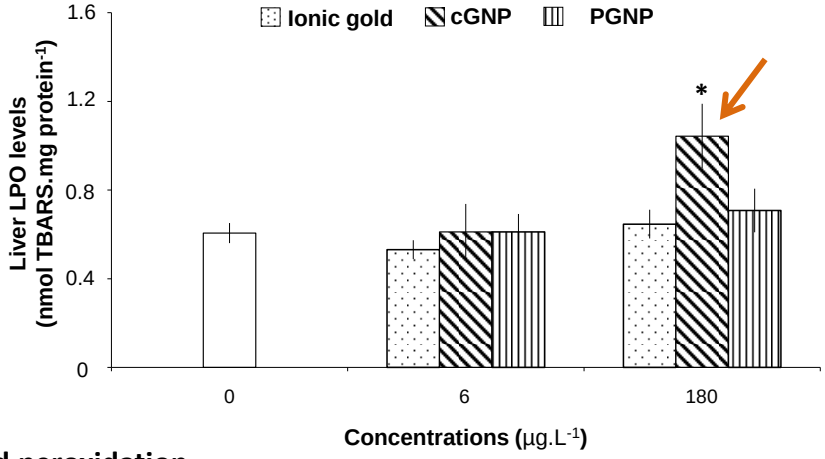
In *S. aurata* gills and liver

In *M. galloprovincialis* liver

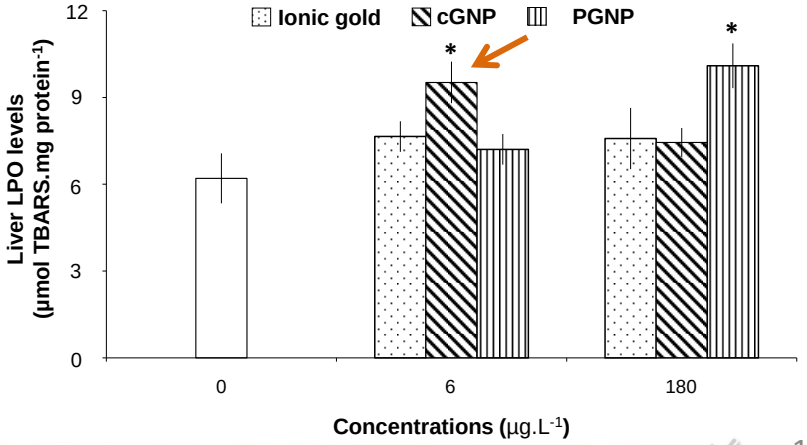
Gills LPO levels



Liver LPO levels



Gold nanoparticles can induce peroxidative damage



LPO, Lipid peroxidation

Conclusions:

- The data show the particle stability in high ionic strength media and the observed effects are highly dependent of the surface coating.

- Some properties of gold nanoparticles (like size, shape, and surface modification) must be considered when considering their toxic effects on the cellular and systematic levels.

- The studied nanoparticles proved able to induce peroxidative damage in gills and liver of both bivalves and fish, and to promote alterations in the neurotransmission as well as in the antioxidant defenses.

- Although the benefits of these nanomaterials are extensively shown, their unintentional release or disposal deserves more care and precaution.

Acknowledgments:

Thank you all for your attention!

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