

Supplementary Information for

## **Tracing the Bioavailability of Three Dimensional Graphene Foam in Biological Tissues**

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**Histological alterations**

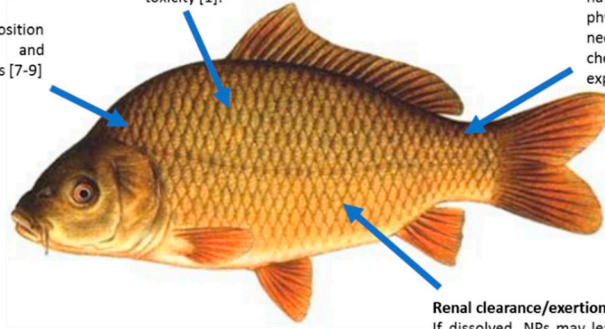
Liver; Karyolitic nuclei in hepatocytes, Karyorrhexis nuclei in hepatocytes, Pyknosed nuclei in hepatocytes, Necrosis, Degeneration of central vein, Degeneration of hepatocytes, Inflammatory cells, Haemorrhage [4-6]  
Renal tissues; Glomerulus shrinkage, Pyknosed nuclei, Congestion, Necrosis, Deposition of Lipofuscin granules, Haemorrhage  
Heart; Condensed pyknosed nuclei, Deposition of Lipofuscin granules, Thinning and degeneration of myofibrils, Haemorrhages [7-9]

**Metabolic responses**

If dissolved, could release toxic effects, may adhere to a cell and block essential membrane function and modalities.  
If not dissolved, may be used as indicator for aquatic ecosystem and provide information for vital enzymes.  
Different concentrations of NPs influence the fish cell metabolism in different ways of toxicity [1].

**Physiological responses and stress protein profiling**

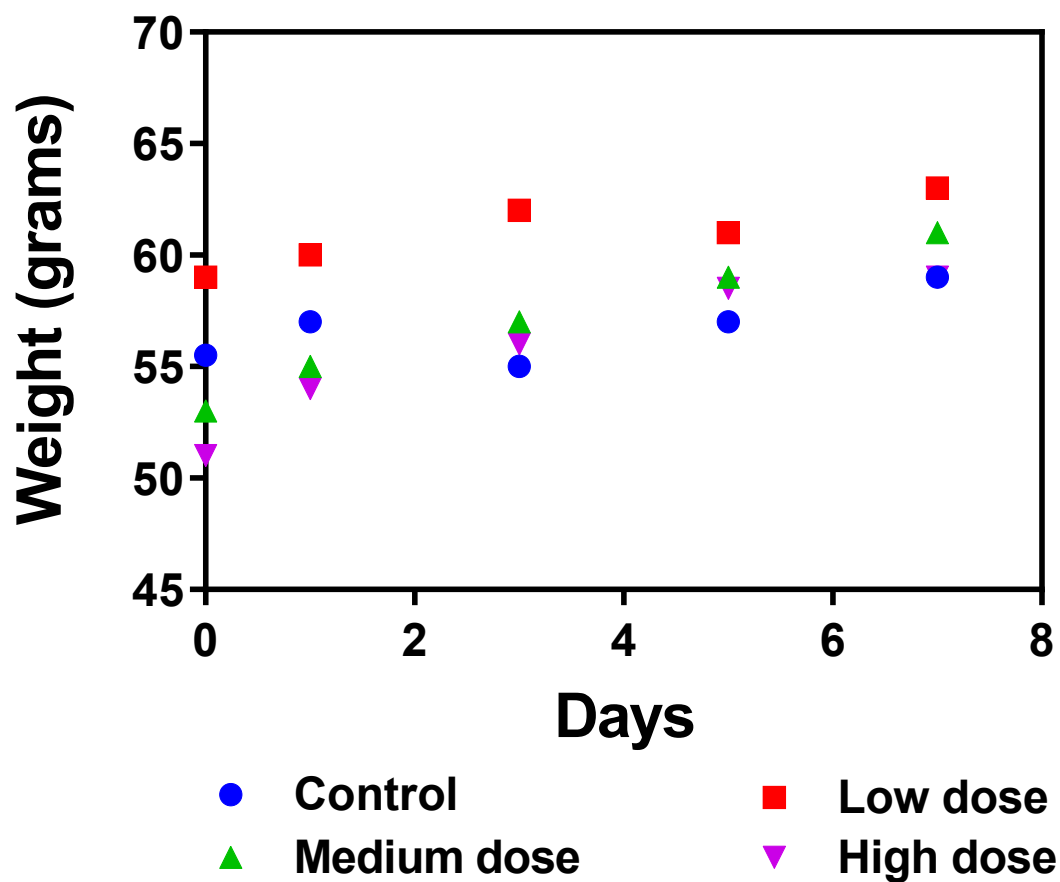
Physiological and biochemical features represents the toxicity caused by NPs exposure. Different family members of protein such as HSPs play a key role in stress profiling at cellular levels. It also represents bioaccumulations, absorption and bio-distribution of NPs. Variety of biomarkers have been developed to quantify physiological condition status. It is also necessary to maintain the physical and chemical indices of water during NPs exposure time [3].



**Renal clearance/excretion**

If dissolved, NPs may lead to disintegration of renal epithelium, displacement of nuclei, shrinkage of glomeruli and infiltration by inflammatory cells [2].

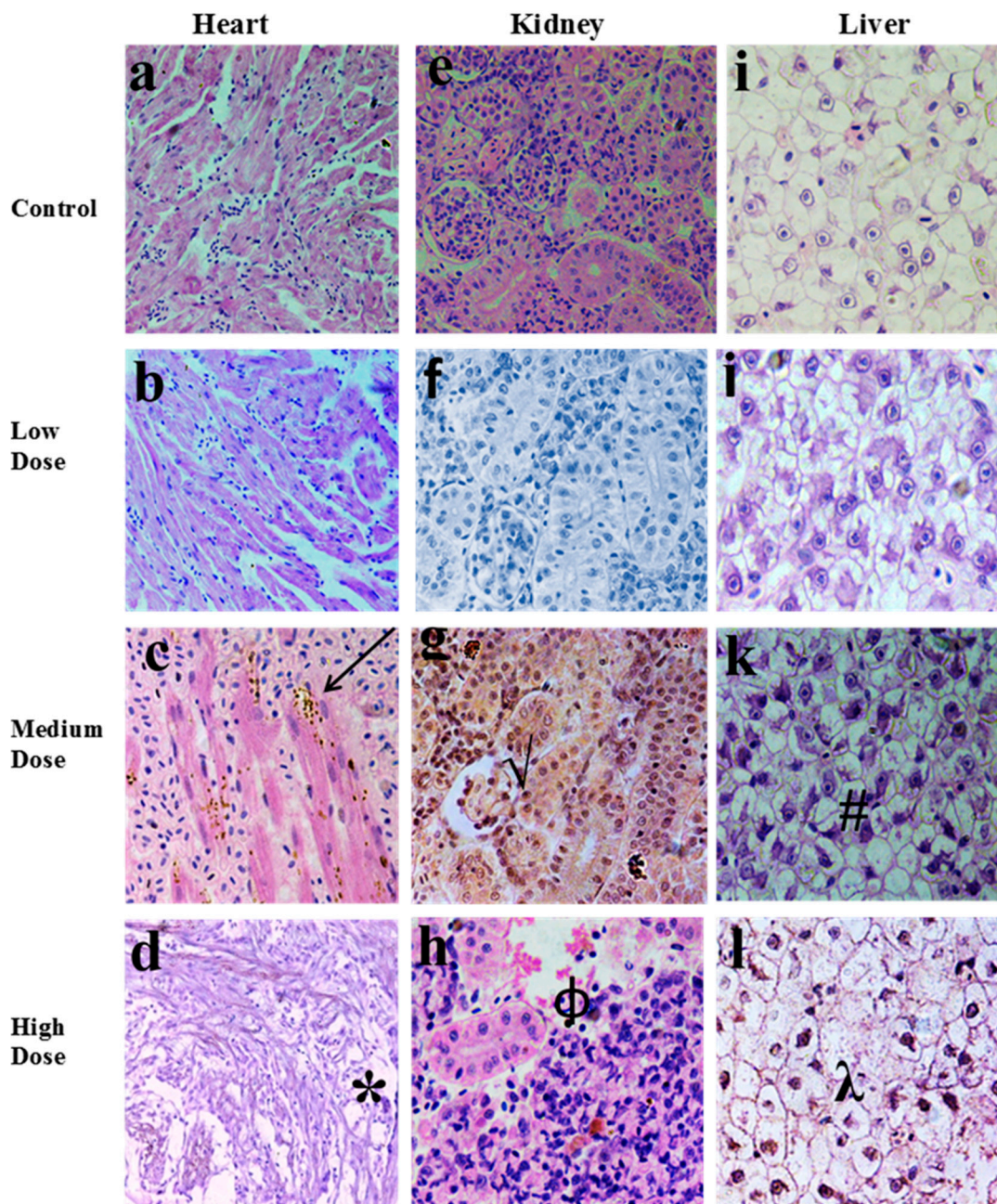
**Figure S1. Schematic diagram showing toxicology mechanism of NPs in fish.**



**Figure S2.** Mean and standard deviations of body weight of common carp treated with GF show no statistically substantial changes over a period of 7 days. Data are presented as mean  $\pm$  SE (n = 3).

**Table S1. Histological findings in fish after treatment with GF for 7 days.** Histological changes were observed in both control and treated groups and indicated by + and – (where + means this is found in particular tissue, ++ means this is highly noted in particular tissue, and – means it is not found in the tissue).

Histological alteration	Control	Low dose	Medium dose	High dose
<b>Liver</b>				
Karyolitic nuclei in hepatocytes	-	-	+	++
Karyorrhesis nuclei in hepatocytes	-	-	+	++
Pyknosed nuclei in hepatocytes	-	-	+	++
Necrosis	-	-	+	++
Degeneration of central vein	-	-	+	++
Degeneration of hepatocytes	-	-	+	++
Inflammatory cells	-	-	+	++
Hemorrhage	-	-	-	++
<b>Renal tissue</b>				
Glomerulus shrinkage	-	-	+	++
Pyknosed nuclei	-	-	+	++
Congestion	-	-	+	++
Necrosis	-	-	+	+
Deposition of Lipofuscin granules	-	-	+	-
Haemorrhage	-	-	-	++
<b>Heart</b>				
Condensed pyknosed nuclei	-	-	-	-
Deposition of Lipofuscin granules	-	-	+	-
Thinning and degeneration of myofibrils	-	-	-	+
Haemorrhages	-	-	-	-



**Figure S3.** H & E stained light micrographs of *Cyprinus carpio* {heart (a-d), kidney (e-h) and liver tissues (i-l)} treated with GF in dose dependant manner after 5 days. Figures a-b, e-f and i-j show normal histology of heart, kidney and liver. Figures c-d, g-h and k-l show histological alterations in dose dependent manner in selected tissues. Details of histological alterations are given in Table S2. All the images were taken at 50µm scale bar.

**Table S2 Histological findings in fish after treatment with GF for 5 days.** Histological changes were observed in both control and treated groups and indicated by + and – (where + means this is found in particular tissue, ++ means this is highly noted in particular tissue, and – means it is not found in the tissue).

Histological alteration	Control	Low dose	Medium dose	High dose
<b>Liver</b>				
Karyolitic nuclei in hepatocytes	-	-	+	+
Karyorrhexis nuclei in hepatocytes	-	-	+	++
Pyknosed nuclei in hepatocytes	- -	- -	+	+
Necrosis	- -	- -	+	++
Degeneration of central vein	-	-	+	+
Degeneration of hepatocytes	-	-	+	++
Inflammatory cells	-	-	+	+
Hemorrhage	-	-	-	++
<b>Renal tissue</b>				
Glomerulus shrinkage	-	-	+	+
Pyknosed nuclei	-	-	+	++
Congestion	-	-	+	+
Necrosis	-	-	+	+
Deposition of Lipofuscin granules	-	-	+	-
Haemorrhage	-	-	-	++
<b>Heart</b>				
Condensed pyknosed nuclei	-	-	-	-
Deposition of Lipofuscin granules	-	-	+	-
Thinning and degeneration of myofibrils	-	-	-	+
Haemorrhages	-	-	-	-

## References

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