SLOWER DEVELOPMENT AND HEART RATES MEDAKA FISH EMBRYOS CAUSED BY POLLUTED TIJUANA RIVER SEDIMENT

Pandit A.[1], Lee L.[2], Serrano A.[3], Salazar A.[3], Lu J.[4], Vasquez M.[4], Feng Z.[4], Bozinovic G.[4]

[1]Del Norte High School, [2]Beckman High School, [3]University City High School, [4]Boz Life Science Research and Teaching Institute

BOZ INSTITUTE

WHALE TAIL® LICENSE PLATE — California — Protect Our Coast and Oceans Fund

Abstract

Aquatic environments near industrial and residential areas often contain chemical pollutants that can disrupt normal development in aquatic organisms. This study examined the effects of the Tijuana River Estuary sediment on medaka fish embryo development. Embryos were exposed to different sediment concentrations and were monitored for developmental stage progression and heart rate. Embryos exposed to higher concentrations consistently showed delayed development progression and lower heart rates compared to the control group. Statistical analysis supported the hypothesis that increased pollution exposure delays development and confirmed these differences were significant. These results indicate that sediment pollution from the Tijuana River Estuary can negatively affect fish embryo growth.

Introduction

- **Hypothesis: Embryos exposed to higher concentrations of pollutants[1] will develop slower than those exposed to lower concentrations[2].**
- Aquatic environments located near urban or industrialized areas are often polluted with harmful bacteria, such as pathogens, and dangerous chemicals[3].
- Chemicals such as polyaromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCBs), pesticides, and phthalates[4], can also negatively affect aquatic organisms
- Relatively low levels of PAHs can cause stunted development and abnormal heart rates in zebrafish embryos[1,2].
- The Tijuana River Estuary (TRE) is surrounded by urban zones, resulting in high levels of pollutants[5].
- This study investigates how these chemicals affect fish embryos. Medaka fish were chosen[6] due to their transparent embryos and tolerance to salinity fluctuations. Medaka fish are well-established model organisms for developmental[7] and toxicological assays[8].

Materials & Methods

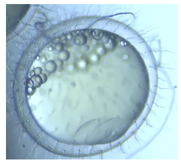
Sediments were collected from four sites, and the most polluted in-land site was used to prepare the elutriate for the exposure assay

Map of the estuary: sediment sample from Site 2 was used for the exposure assay

Collect medaka embryos were split evenly between across 10%, 50%, 75% and 100% sediment elutriate exposures and the control (0%) condition

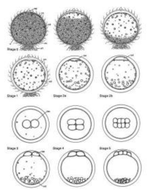
Adults medaka fish

Medaka embryos were kept at a consistent temperature and under a 14h:10h light cycle



Medaka embryo prior to exposure

Medaka embryos were observed at 3 and 7 days post fertilization (dpf) to record survival, development, and heart physiology



Medaka embryo developmental stages

Developmental defects or delays were determined based on their progress compared to the control group

Data were processed and visualized with R (4.5.2) using tidyverse (2.0.0), ggplot2 (4.0.0), stringr (1.6.0), and dplyr (1.1.4).

Results

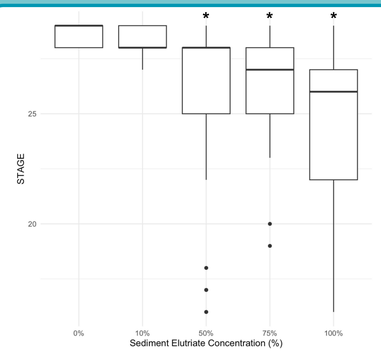


Figure 1: Medaka embryos exposed to higher concentrations of sediment elutriate are more developmentally delayed at 3 days post fertilization. Lines within box represent the median, and outliers are shown as dots. * indicates statistically significant developmental stage difference relative to the control group ($p < 0.001$, Kruskal-Wallis followed by Dunn's test).

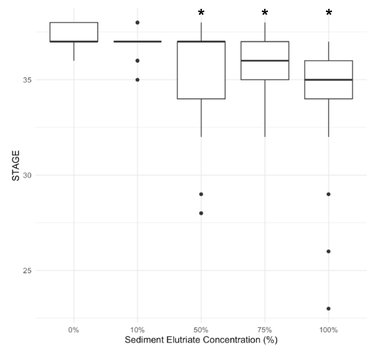


Figure 2: Medaka embryos exposed to higher concentrations of sediment elutriate are more developmentally delayed at 7 days post fertilization. Lines within box represent the median, and outliers are shown as dots. * indicates statistically significant developmental stage difference relative to the control group ($p < 0.001$, Kruskal-Wallis followed by Dunn's test).

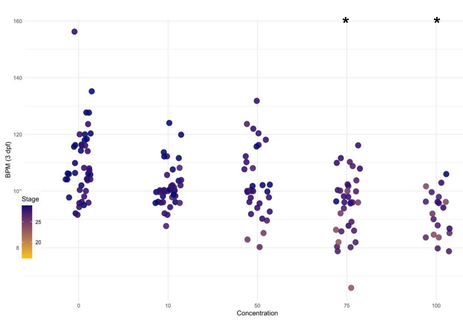


Figure 3: Medaka embryo heart rates at 3 dpf are slower following exposure to higher concentrations of sediment elutriate. Each point represents an individual embryo, with color indicating its developmental stage. * indicates statistically significant heart rate difference relative to the control group ($p < 0.001$, Kruskal-Wallis followed by Dunn's test).

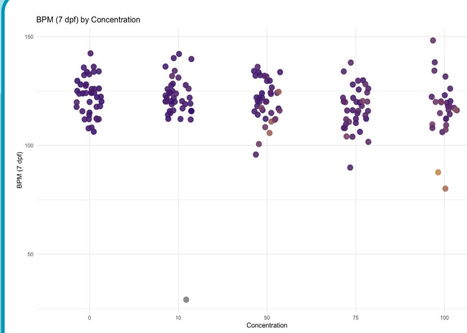


Figure 3: Medaka embryo heart rates at 7 dpf following exposure to sediment elutriate. Each point represents an individual embryo, with color indicating its developmental stage. No statistically significant difference was detected across exposure groups.

Discussion & Future Directions

- Embryos at both 3 dpf and 7 dpf exposed to 50%, 75%, and undiluted sediment elutriate consistently had slower development ($p < 0.001$, Figure 1, 2).
- Developmental delay is a common outcome following exposure to pollutants[1, 2, 4].

- Embryos at both 3 dpf and 7 dpf exposed to higher concentrations of sediment elutriate consistently had slower heart rates compared to the control (Figure 3, 4).
- Lower heart rates are expected with slower development.

- Pollutants in the Tijuana River may have induced metabolic burden or disrupted relevant signaling pathways within exposed embryos which cause the slower growth rates and heart rates compared to the control group[11].
- PAHs, which are abundant in TRE, could have contributed to the developmental and heart physiology effects observed in the embryos [4,12, 13].

- Our study did not identify the specific contaminants responsible for developmental delays.
- Our next step is to chemically characterize the embryos to quantify the exposure levels and determine relevant toxicological effects.

- Exposure was carried out in a lab setting, and carrying out this study in a more realistic setting mimicking the environment of the Tijuana River could make the results more relevant
- Estuarine environment changes with the tides and seasons, which could affect pollutant abundance and toxicity.

- Future studies should evaluate the effects of the pollution among native species[14].
- Embryo development is regulated by a range of signaling pathways[15], and identifying possible disrupting effects of pollutants, if any, could help evaluate the ecological risk of sediment pollution on native fish in the estuary.

Works Cited