Effect of environmental factors on physiology of fish

Major environmental factors that effect the physiology of fishes

- **Temperature**
- **Salinity**
- **DO**
- **pH**

Temperature

- A slight increase in temperature is beneficial to physiological rates, resulting in more energy, higher rates of diffusion and more enzyme-substrate complexes producing higher reaction rates for growth, maturation, etc. However, higher temperatures, beyond tolerance limits results in negative impacts to physiology, as cardiac output cannot keep pace with increased metabolic demands.

Response to increase in temperature:

- Loss of plasma electrolyte (dehydration)and shift of water out of cells which increase the extracellular volume.
- Change in spawning activity:

  1. Disrupt the gonadal maturation in both genders.

  2. Low levels of plasma sex steroids.

  3. Reduced level of male 11-ketotestosterone cause deleterious effects on spermatogenesis.
- Increase heart rate and cardiac output

Response to decrease in temperature

- Loss of plasma chloride.
- Decrease in heart rate.
- Delay in sexual maturation.
- Slow growth and feed conversion ratio.

Response to change in Salinity

- Change in salinity affect the egg fertilization and incubation, yolk sac resorption, early embryogenesis, swim bladder inflation, larval growth.
- Increase secretion of oxytocin and vasopressin
- Increase in osmoregulation activity
- Decrease in overall growth
- Decrease in food conversion ratio
- Alteration in intestinal bicarbonate secretion

Response to change in Salinity

- Exposure to hypersalinity increases characteristic traits related to osmoregulation exhibited by fish in seawater (e.g. increased drinking rate, plasma osmotic pressure, intestinal absorption and plasma concentrations of Na + and Cl - , Na + - K + Fish exposed to high salinity also increase HCO_3- ATPase activity in the gut and gill).

- Environmental salinity also influenced the relative appearance of lactate and metabolic acid in the extracellular fluid compartment, with full-strength salinity favouring the relative appearance of lactate in the blood.

Fish response to hypoxia

- Hypoxia or oxygen depletion is a phenomenon that occurs in aquatic environments as dissolved oxygen (DO; molecular oxygen dissolved in water) becomes reduced in concentration to a point detrimental to aquatic organisms living in the system.

- At low DO, the blood flow can be increased by opening up further secondary lamellae to increase the effective respiratory area and the concentration of red blood corpuscles can be increased to raise the oxygen carrying capacity of the blood per unit volume. The latter can be achieved by reducing the blood plasma volume (e.g. by increasing the urine flow rate) in the short term, and by releasing extra blood corpuscles from the spleen in the longer term.

- Increase in ventilation rate is increased to bring more water into contact with the gills within a unit of time.

Fish response to hypoxia

- The major pathological-anatomic changes include a very pale skin colour, adherence of the gill lamellae, and small haemorrhages in the front of the ocular cavity and in the skin of the gill covers.
- Fish reduce food intake, leading to a reduction in growth.
- Reproduction is inhibited, and both fertilisation success and larval survival are compromised.
- Energy utilisation is decreased, associated with a shift from aerobic to anaerobic metabolism.
- Transcription is reduced, mediated by increased levels of hypoxia-inducing factor 1 (HIF-1), which also up-regulates genes involved in erythropoiesis, capillary growth and glucose transport.

Fish response to hyperoxia

- Hyperoxia is the state of water when it holds a very high amount of oxygen.
- If fish are exposed (at a lower atmospheric pressure) to such water, their blood equilibrates with the excess pressure in the water. Bubbles form in the blood and these can block the capillaries; in sub-acute cases the dorsal and caudal fin can be affected, and bubbles may be visible between the fin rays.
- In severe cases, death occurs rapidly as a result of blockage of the major arteries
- The epidermal tissue distal to the occlusions then becomes necrotic.
- When the water is supersaturated (hyperoxia) the bladder becomes over-inflated and this leads to buoyancy problems especially in small fishes

Response to low pH

- Levels of pH 4 constitute acidic conditions lethal to most species of fish.

- When fish were exposed to low pH, loss of sodium (Na^+) and chloride (Cl^-) ions from the body fluid occurred, resulting in a decrease in plasma osmotic pressure.

- At low pH, gill chloride cells showed high V-ATPase activity that stimulates the proton pump of the cell membrane to excrete H^+ ions.

- Decrease in pH also reduce the oxygen carrying capacity of hemoglobin.

Response to low pH

- Even if pH is not low enough to be lethal, the stress of acidification induces various physiological and ecological problems in fish.

- At low pH, plasma cortisol levels peaked in response to acid stress, and immunoglobulin (IgM) levels subsequently decreased. This suggests that acid stress depresses the immune system of fish.

- At low pH, plasma levels of sex steroids and gonadotropin exhibited abnormally high levels and there was a possibility that acid stress disrupted the endocrine control over reproduction