BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI

Original application No. 1119/2024

In the Case of: News item titled "Sindh Nallah Polluted Trout Habitat threatened in Ganderbal" appearing in Greater Kashmir dated 19-08-2024

Applicant...

Versus

Central Pollution Control Board and others

Respondents…

In the Matter Of: Compliance report regarding disclosure of requirement and survival of Trout Fishes.

May it please Your Lordships:

1. That the Hon'ble Tribunal vide order dated 12-08-2025 was pleased to direct that "**state Fisheries Department is required to disclose about the survival and requirement of Trout Fisheries**".

2. That in compliance to the directions of the Hon'ble Tribunal, a detailed report on survival requirements of Trout is annexed herewith as Annexure-I for kind perusal of the Hon'ble Tribunal.

Director Fisheries,
J&K

DIRECTOR FISHERIES
J&K Government

Report on Survival Requirements of Trout

1.Introduction

Trout are cold-water fish species recognized globally for their ecological, recreational, and commercial importance. In the Union Territory of Jammu and Kashmir, trout are represented by two introduced species: Rainbow trout (*Oncorhynchus mykiss*), native to the Pacific coast of North America, and Brown trout (*Salmotruttafario*), native to Europe and Western Asia.These species were introduced to the Kashmir Valley in the late 19th and early 20th centuries, and they have successfully adapted to the unique aquatic ecosystems of the UT. Rainbow trout is primarily cultured under captive conditions due to its faster growth and adaptability tosuch conditions, while Brown trout continues to support the recreational / sport fishery, particularly in natural streams and rivers [1]. Trout can be found in all the streams and Nallahs of the valley. The important ones are Lidder, Wangath, Gurez, Hamal, Lam, Sindh, Kishenganga, Sukhnag, Doodhganga, Erin, Ferozpur(Tangmarg), Bringi, Aharbal, Hirpora, Dachigam, Kokernag, Naristan, Madhumati and Nowbugh [1,2].Trout production in Jammu and Kashmir has steadily increased, reaching around 2,650 tonnes in the financial year 2024–25, makingJ&Ka leading trout producing region in India [2].

2. Survival requirements of Trout

2.1 Habitat

Both Rainbow trout and Brown trout species thrive in cool, well-oxygenated waters with swift flow and gravel substrates fed by snowmelt waters, springs or glaciers. These environments provide stable temperatures, clean gravel beds and high dissolved oxygen levels that support their growth and reproduction.To complete their life cycle,

(Fig.1)wild trout require three primary types of habitat. For spawning and incubation, they depend on clean, loose gravel that allows oxygenated water to flow through, ideally located near deep water or protective cover to safeguard vulnerable adults during reproduction. Juvenile trout need shallow areas with submerged rocks or dense structures that provide shelter from predators and protect them during winter. Adult trout inhabit deeper pools, usually greater than 30 cm in depth, with nearby structural cover such as undercut banks, boulders, sunken logs or low overhanging vegetation within close proximity to the water surface.

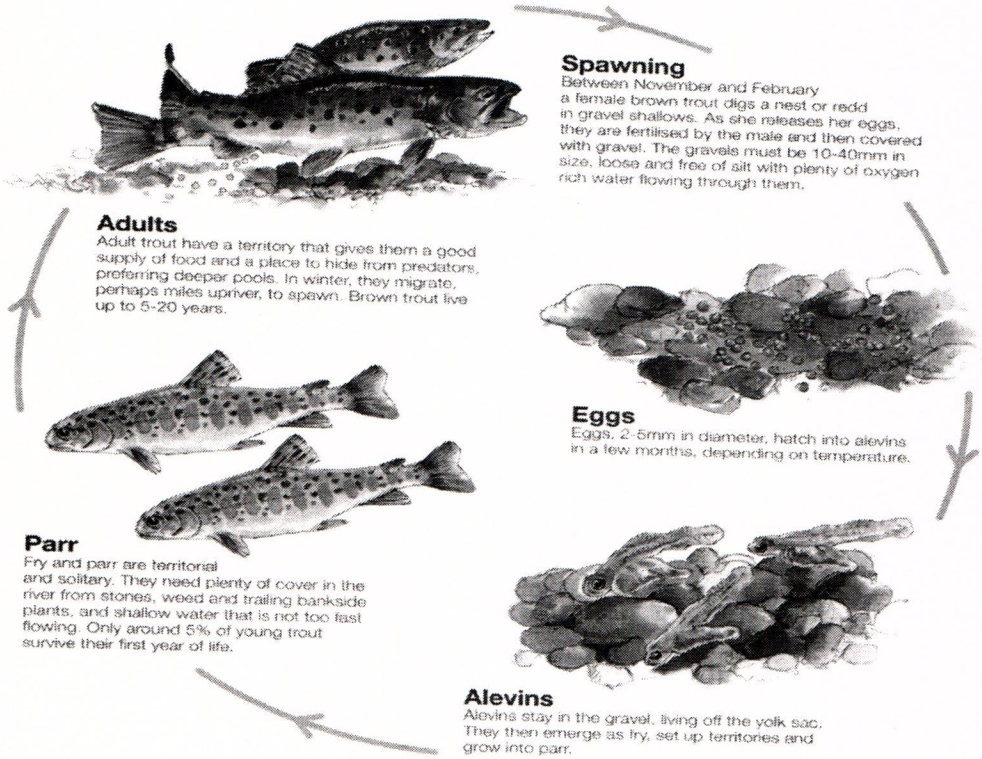

Fig.1. Life cycle of Brown trout

(https://www.wildtrout.org/content/trout-lifecycle)

The life cycle of Rainbow trout is similar to Brown trout. Eggs take 20–100 days to hatch, depending on water temperature. Once hatched the alevins (fry with yolk sacs attached) stay in the gravel for two to three weeks and feed off their yolk sacs. When the yolks are nearly used up, the young trout emerge as free-swimming fry.

Trout are carnivorous by nature, and their diet in the wild consists of aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, minnows and other small fish. Among these, freshwater shrimp are particularly significant as they contain carotenoid pigments responsible for the orange-pink coloration of trout flesh [3]. Under culture conditions, trout are fed nutritionally balanced, formulated pellet diets containing appropriate levels of proteins, lipids, vitamins, and minerals [4].

Due to their sensitivity to environmental changes, any deterioration in water quality such as increased temperature, low dissolved oxygen or elevated ammonia and nitrite levels can significantly affect trout health and increase susceptibility to stress and disease [5]. Whether in natural habitats or culture systems, maintaining optimal physico-chemical conditions isessential for growth, survival and sustainability of trout populations. The key physico-chemical parameters required for optimal growth and survival of trout are as:

2.1.1. pH of water

pH plays a critical role in aquatic ecosystems by directly influencing the health, metabolism, and reproductive success of fish. pH affects the solubility and toxicity of various chemical compounds, including ammonia and heavy metals. Even slight deviations from the optimal pH range can cause physiological stress in trout, negatively impacting survival, growth, and egg development. For instance, low pH levels (4.5–5.5) have been associated with reduced hatching success of rainbow trout eggs, while no survival of embryos or alevinshas been found at pH 4.3 or below [6,7]. Similarly, survival of less than 1.0% for brown trout embryos was observed in waters with pH values between 4.0 and 4.8[8].A neutral or slightly alkaline pH is best for the trout, with an optimum pH level of 6.7–8.5 ideal for their growth and survival [19].

2.1.2. Temperature

Temperature is a key factor in trout aquaculture, affecting physiology, growth, metabolism, immune function, and reproduction of fish. Rainbow trout tolerate a wide range of temperature (0°C to 25°C), with optimal growth between 10°C -20°C[9]. Brown trout have narrower thermal limits ranging from 4°C-20°Cand optimal growth occurring between 13°C-18°C [10]. Rapid or frequent temperature changes can disrupt feeding, impair growth, weaken immunity, and increase vulnerability of trout to disease and mortality [5].

2.1.3. Dissolved oxygen (DO)

Dissolved oxygen is crucial for the survival and health of fish, as it directly influences key physiological processes such as respiration, metabolism, growth, and immune function. As cold-water species, trout are particularly sensitive to low DO levels, especially at higher temperatures where oxygen availability decreases. Oxygen concentration has been identified as the critical factor for the survival of trout from spawning to hatching [11]. Inadequate DO levels can lead to stress, reduced feeding and growth, greater disease risk, and, mortality in extreme cases. Sudden or large fluctuations in DO can cause asphyxiation of embryos and larvae of trout[12]. Both species tolerate DO concentrations between 5.8 and 9 mg/L, but optimal growth and survival occur within the 7 to 9 mg/L range. DO levels below 5 mg/L are considered harmful for trout, potentially causing physiological stress, reduced immunity, and increased risk to mortality [5].

2.1.4. Clarity and Turbidity

Turbidity is a measure of the relative clarity of water and is influenced by the presence of materials such as clay, silt, fine inorganic and organic matter, algae, dissolved colored compounds, plankton, and other microscopic organisms. Trout, being visual predators, rely on clear water for

efficient feeding. Increased turbidity reduces their foraging radius and efficiency, forcing them to expend more energy to locate food, which can further suppress growth in food-limited environments [5]. High loads of fine sediment in rivers are known to impact fish by damaging sensitive tissues such as gill filaments, increasing the risk of disease and potentially leading to mortality in extreme cases[13]. Additionally, fine sediment deposition degrades spawning habitat and reduces shelter for both juvenile and adult trout, negatively affecting trout survival and development. In culture systems, maintaining water clarity is essentialfor optimal growth and survival of trout, and turbidity shall not exceed 25 cm when measured with a Secchi disc[4].

2.1.5. Ammonia

In natural waters, ammonia typically poses little risk to fish due to dilution and reduced toxicity at neutral or acidic pH [14]. In intensive culture systems or alkaline waters (pH > 8), however, ammonia becomes more toxic as the un-ionised form (NH_3) increases. Levels above 0.02 mg/L NH_3-N can reduce growth and lead to sub-lethal effects including gill damage and increased disease susceptibility and may predispose fish to higher rates of bacterial infections, especially in poor quality water[5]. Fin erosion has also been linked to NH_3 exposure in rainbow and brown trout[15]. It is generally recommended that the level of ammonia as NH_3 be kept below 0.01 mg/L for successful troutculture [5].

2.1.6. Waterhardness

Water hardness is the total concentration of Calcium and Magnesium salts in culture water, often expressed as calcium carbonate ($CaCO_3$) levels. It is important in trout culture because it affects the solubility and prevents toxicity of ions such as copper and zinc, which can enter fish through the gills, especially as pH decreases [16]. To prevent ion toxicity in soft waters,

hardness should be maintained above 200 mg/L as $CaCO_3$[14, 16]. Maintaining proper hardness also buffers acidic waters and reduces disease risk in trout culture [16].

2.2. Toxins: Trace metals, heavy metals and poisons

Numerous studies have evaluated the effects of heavy metals, trace elements, and other toxins on trout. Aluminium (Al) and copper (Cu) were generallyfound most toxic, especially under acidic conditions. Copper toxicity, though requiring relatively high concentrations to cause mortality, increases sharply in soft water [17]. Aluminium causes immediate effects in acidic waters, including excessive mucus production (micification) on the gills and "coughing" due to aluminum ion deposits disrupting gas exchange. A range of studies have evaluated the effects of various metals and toxins on trout (Table 1).

Table 1: Summary of experiments evaluating the effects of some compounds or elements on trout

Species	Element/ Compound	Conc	Effects	Ref
O. mykiss	Aluminum	0–400 µg/L	Higher mortality at low pH; mucous buildup on gills	[5]
O. mykiss	Cadmium	0–5 µg/L	Increased embryo/larvae mortality	[5]
O. mykiss	Copper (dietary)	0–730 mg/kg	Mortality at 730 mg/kg	[5]
O. mykiss	Copper (waterborne)	5–106 µg/L	Gill permeability changes	[5]
O. mykiss	Zinc	0.1–10 mg/L	Low pH increases toxicity; gill and kidney damage	[5]
S. trutta	Multiple metals	Various	Cu and Al most toxic	[5]
O. mykiss	Sumithion (insecticide)	12.8–42.4 ppm	Higher temperature increased mortality	[5]
O. mykiss	Cypermethrin	1.4–2.52 µg/L	LC50 within 96 h	[5]

2.3. Synergistic interactions

Fish growth and survival are influenced not just by individual environmental factors, but by their interactions (synergy). For example, rising water temperature not only increases fish metabolism but also lowers oxygen availability and raises oxygen demand, especially after feeding. It also shifts the balance of ammonia toward the more toxic NH_3, a process intensified by high pH and temperature. Elevated ammonia levels further reduce dissolved oxygen due to organic matter breakdown[5].

2.4. Environmental requirements for trout in rivers and streams

Besides suitable physical water conditions and chemistry, specific environmental factors in streams and rivers are essential for trout survival, growth, and successful stocking. In regions like Jammu and Kashmir, little is known about the habitat requirements of introduced trout species, which often show limited natural reproduction in wild and rely on regular stocking. Studies from North America and Europe have identified key habitat variables explaining most variation in abundance of trout in streams and rivers[5, 17, 18].

2.4.1. Late Summer Stream-flow:

The flow at the end of summer should be high enough to support maximal trout numbers. An approximate calculation was used where average daily late summer flow needed to be greater than 55% of the average daily flow rate for the year. That is, perennial streams were preferred by trout.

2.4.2. Annual Stream-flow Variation:

Stable flow throughout the year supports higher trout densities; intermittent streams are less suitable.

2.4.3. Water Velocity

Highest trout densities were found in the fastest flowing waters (based on volume throughput estimates of individual streams). The highest trout densities were recorded in water velocities of 45.6 – 76.0 cm/sec. However, trout have also been recorded in high abundance in water speeds exceeding 156-321 cm/sec.

2.4.4. Cover

Coveris defined as sheltered areas in a stream where trout can rest or hide from predators (i.e. snags, logs, undercut banks, large rocks, etc.), was positively correlated with trout abundance. The best trout areas had in excess of 55% of the available area of the stream containing some form of cover. The most inadequate streams still had cover, but less than 10% of the area of a stream.

2.4.5. ErodingStreamBanks

The presence of eroding banks (expressed as a percentage of total bank length) was also highly correlated with trout density. The highest abundances of trout were found where little or no erosion was evident (0-9%).

2.4.6. Substrate

In this instance, the substrate referred to the presence of aquatic vegetation (including macro-algae and moss) which was indicative of the amount of fish. The more abundant macro-algae were at a site, the more habitat for food items and thus the higher the density of trout.

2.4.7. Maximum Summer Water Temperature

Optimal trout densities were found at 12.6–18.6 °C. Few trout were found below 6 °C or above 26.4 °C.

Table 2: Summaryof the growth requirementsfor Rainbow and Brown trout

Parameter	Range	Ref
Optimal Temperature (°C)	10°C – 20 °C (R.T) 13-18 °C (B.T)	[9,10]
Optimal pH range	6.5-8.5	[19]
Dissolved oxygen (mg/L)	5.8-9.5	[4]
Ammonia (NH_3-N mg/L	<0.01	[5]
Hardness(mg/L as $CaCO_3$)	10-400	[20]
Alkalinity	30 – 200	[19]
Ammonia-N (mg/L)	0.01	
Nitrate (mg/L)	< 0.1 in soft water < 0.2 in hard water	[20]
Manganese (mg/L)	<0.01	[3]
Iron (mg/L)	<1.0	[3]
Zinc (mg/L)	<0.05	[3]
Copper (mg/L)	<0.006 in soft water <0.3 in hard water.	[3]

3. Conclusion

The survival and growth of trout depend on a combination of good water quality parameters under both culture conditions and in stream/river habitats. Both Rainbow and Brown trout prefer cold waters with stable temperatures, neutral to slightly alkaline pH, and adequate dissolved oxygen levels. They are highly sensitive to pollutants such as agricultural runoff, sewage, and industrial waste along with low dissolved oxygen, high ammonia, or rapid changes in temperature that can quickly lead to stress, disease, and mortality. In natural streams and rivers, clean gravel beds are essential for spawning, while adequate shelter, steady flows, and stable banks improve survival of juveniles and adults. Water turbidity and fine sediments reduce feeding efficiency, damage gills, and degrade spawning grounds, while pollution from heavy metals, pesticides, or nutrient enrichment furtheraffects trout health by altering water chemistry and increasing stress, disease risks, and mortality in extreme cases.

4. References

1. Shah, F. A., Maqbool, H., Hafeez, M., & Bhat, F. A. (2023). History, Present Status and Strategies of Rainbow Trout (Oncorhynchus mykiss) Farming in Jammu and Kashmir, India-A Review. *Fishery Technology*, *60*(3).
2. Department of Fisheries, Jammu & Kashmir (https://fisheries.jk.gov.in/)
3. FAO. 2025. Oncorhynchus mykiss. Cultured Aquatic Species Information Programme. Text by Cowx, I. G.. In: *Fisheries and Aquaculture*. [Cited Sunday, September 7th 2025].
4. https://nfdb.gov.in/PDF/03_TCR%20Brochure_Eng.pdf
5. Molony, B., & Molony, B. (2001). *Environmental requirements and tolerances of rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta) with special reference to Western Australia: a review* (Vol. 130, pp. 1-32). Perth, Australia: Department of Fisheries, Government of Western Australia.
6. Thomsen, A., Korsgaard, B., & Joensen, J. (1988). Effect of aluminium and calcium ions on survival and physiology of rainbow trout Salmogairdneri (Richardson) eggs and larvae exposed to acid stress. *Aquatic toxicology*, *12*(4), 291-300.
7. Daye, P. G. (1980). Attempts to acclimate embryos and alevins of Atlantic salmon, Salmosalar, and rainbow trout, S. gairdneri, to low pH. *Canadian Journal of Fisheries and Aquatic Sciences*, *37*(6), 1035-1038.
8. Barlaup, B. T., Hindar, A., Kleiven, E., &Høgberget, R. (1998). Incomplete mixing of limed water and acidic runoff restricts recruitment of lake spawning brown trout in Hovvatn, southern Norway. *Environmental biology of fishes*, *53*(1), 47-63.
9. Adeli, A., &Baghaei, F. (2013). Production and supply of rainbow trout in Iran and the world
10. Hampuwo, Buumba, Anna Duenser, and Franz Lahnsteiner. "Effects of elevated temperature on gene expression, energy metabolism, and physiology in brown trout, Salmo trutta." *Conservation Physiology* 13, no. 1 (2025): coaf025.
11. Rubin, J. F. (1998). Survival and emergence pattern of sea trout fry in substrata of different compositions. Journal of Fish Biology, 53(1), 84-92.
12. Bjornn, T.C. and Reiser, D.W. (1991) Habitat Requirements of Salmonids in Streams. In: Meehan, W.R., Ed., Influences of Forest and Rangeland Managementon Salmonid Fishes and Their Habitats, American Fisheries Society Special Publication, 19, 83-138.
13. Ryan, P. A. (1991). Environmental effects of sediment on New Zealand streams: a review. *New Zealand journal of marine and freshwater research*, *25*(2), 207-221.

14. Barton, B. A. (1996). General biology of salmonids. *Developments in aquaculture and fisheries science*, *29*, 29-95.
15. Bosakowski, T., & Wagner, E. J. (1994). A survey of trout fin erosion, water quality, and rearing conditions at state fish hatcheries in Utah. *Journal of the World Aquaculture Society*, *25*(2), 308-316.
16. Wedemeyer, G. (1996). *Physiology of fish in intensive culture systems*. Springer Science & Business Media.
17. Hellawell, J. M. (Ed.). (2012). *Biological indicators of freshwater pollution and environmental management*. Springer Science & Business Media.
18. Varley, J. D., & Gresswell, R. E. (1988). *Ecology, status, and management of the Yellowstone cutthroat trout*. The Society.
19. Klontz, G. (1991). Manual for rainbow trout production on the family-owned. *Moscow: Department of Fish and Wildlife Resources, University of Idaho*.
20. Idaho, D. E. Q. (1998). Idaho Waste Management Guidelines for Aquaculture Operations. *Idaho Department of Health and Welfare, Division of Environmental Quality, Twin Falls, ID*.

Appendix -I

Glossary

Alkalinity
The capacity of water to neutralize acids, mainly due to carbonate and bicarbonate ions; it helps stabilize pH levels in trout habitats.

Ammonia (NH_3 and NH_4^+)
A nitrogenous waste product that exists in un-ionized (NH_3, toxic) and ionized (NH_4^+, less toxic) forms; elevated levels harm trout health.

Ammonia-N (mg/L)
Measurement of ammonia nitrogen concentration in water, critical for maintaining safe levels in trout culture.

Aquatic insects
Insects living in water that serve as a primary food source for wild trout.

Biomass
The total mass of living trout in a given culture system or natural habitat.

Carnivorous
Describes animals, like trout, that primarily eat other animals (insects, small fish).

Clarity (Water clarity)
The transparency of water, essential for trout feeding efficiency since they rely on sight to hunt.

Cold-water fish
Fish species that require cool water temperatures, generally below 20°C, for optimal survival and growth.

Coughing in fish
Reflex action in which a fish forcefully expels water through its gills or mouth to clear irritants such as mucus, parasites, or suspended particles, and is often an indicator of gill irritation or poor water quality.

Cover
Physical structures (e.g., rocks, logs, undercut banks) in streams providing shelter and protection to trout.

Culture system
Controlled environment (e.g., hatchery, fish farm) where trout are raised commercially.

Dissolved oxygen (DO)
The amount of oxygen dissolved in water, vital for trout respiration and survival

Erosion (Stream bank erosion)
The wearing away of stream banks, negatively affecting trout habitat by increasing sedimentation.

Growth
Increase in size and weight of trout influenced by environmental conditions and nutrition.

Habitat
The natural environment where trout live, including physical, chemical, and biological factors.

Hard water

Water with high calcium and magnesium content, usually above 120 mg/L as $CaCO_3$.

Hatching success
The percentage of eggs that successfully develop and hatch into viable trout larvae.

Heavy metals
Toxic metals such as copper, zinc, and aluminum that can harm trout at certain concentrations.

Intermittent:

Stream that has flowing water during certain times of the year, whengroundwater provideswater for stream flow. During dry periods, intermittent streams may not have flowing water.

LC_{50} (Lethal Concentration 50%)
Concentration of a substance that kills 50% of test organisms within a specified period, used to measure toxicity.

Life cycle
The series of stages trout go through from egg to adult.

Nitrate
A form of nitrogen found in water that at high levels can be harmful to trout.

Optimal pH
The pH range where trout exhibit best growth, survival, and reproduction.

Optimal temperature
The temperature range preferred by trout for best physiological functioning

Oxygendemand
The amount of oxygen needed by trout for metabolism and physiological processes.

pH
A numeric scale measuring the acidity or alkalinity of water; important for chemical balance and trout health.

Perenial stream

A stream that has flowing water year-round during a typical year.

Sediment

Particles like clay and silt suspended or settled in water, which can reduce water quality and damage trout gills.

Soft Water

Water containing low levels of Calcium and Magnesium,typically less than 60 mg/L as $CaCO_3$.

Spawning

Biological process where a parent fish or other aquatic animal releases mature eggs and sperm into the water for fertilization

Spawning habitat

Clean gravel areas in streams where trout deposit eggs and complete early development stages.

Sport fishery

Also known as recreational fishing, is the activity of catching fish for pleasure, leisure, or competition, rather than for commercial sale or survival. It often involves techniques like angling with a rod, line, and hook

Stream substrate

The physical composition of the streambed (gravel, rocks, vegetation) affecting trout habitat quality.

Stream velocity

The speed of water flow in streams; moderate to fast velocities support higher trout densities.

Stress

Physiological or behavioral strain on trout caused by environmental changes like temperature fluctuations or poor water quality.

Temperature tolerance

Range of water temperatures trout can survive

Toxicity

The degree to which substances (pollutants, metals) cause harm to trout.

Turbidity

The cloudiness or haziness of water due to suspended particles, negatively impacting trout feeding and health.

Un-ionized ammonia (NH_3)

The toxic form of ammonia in water that increases with higher pH and temperature.

Water hardness

Concentration of calcium and magnesium ions in water, influencing trout health and buffering against toxins.

Water quality

Physical, chemical, and biological characteristics of water, crucial for trout survival and growth.