

TOXICITY OF DIFFERENT TYPES OF WASTE ON THE FISH *THERAPON JARBUA* (FORSSKAL, 1775)

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ABSTRACT

Bioassay tests were conducted for evaluating the toxicity of different types of industrial waste on the fish *Therapon jarbua*. The effluent from soda ash factory appeared to be the most toxic and LC10 for 96 hr was at a range of 5.5-9.5% concentration. LC10 for 96 hr for fertilizer effluent was observed at a concentration of 35% while that for the refinery effluent showed inconsistent values. The major toxic substances in the different types of effluent and their effect on marine life are discussed. The importance of data on toxicity testing to evaluate the degree of dilution and dispersion needed to render the waste harmless has been emphasized.

INTRODUCTION

The hazards of pollution have created an awareness on the treatment of waste before disposal for bringing down the levels of various toxicants to suit the water quality standard set up by the Pollution Control Board. Due to the complexity of the marine communities and the number of environmental factors acting upon them, it is difficult to clearly identify and evaluate the adverse effect of toxicants on marine life under natural condition. However, many agencies contemplating on disposal of effluent take up bioassay studies as an alternate measure by employing a single species which is exposed to the pollutant under controlled conditions¹. These acute toxicity tests specify the degree of dilution and dispersion needed to render the waste harmless². Eventhough the advantage of including toxicity testing as a control parameter has given an upsurge for such laboratory studies, in India, this aspect of environmental monitoring has not received due attention and there are only limited reports on this³⁻⁶. The present communication is on the toxicity of six types of effluent on the coastal marine fish *Therapon jarbua*.

MATERIALS AND METHODS

Static bioassay tests were conducted as per standard procedure⁷⁻⁹. Initially screening tests were done to ascertain the lethal and sublethal concentrations of the waste and based on the results the definitive tests were carried out. Experiments were conducted at room temperature. Each test consisted of a series of dilutions and a control. Each dilution was run in triplicate and experiments were repeated till comparable results were obtained. Mean values of comparable results are presented in tables and figure.

The fish selected for bioassay was *Therapon jarbua* (Forsskal, 1775), a very common fish found along the nearshore waters of India. Juveniles of *T. jarbua* were collected from a clean area and acclimatised for a week. They were fed normally except for 24hr. preceding the test. The fish selected for the test varied in length from 2.5 to 3.5cm and weighed between 0.3 to 0.8g. Loading of the fish was done at the rate of 1 fish/litre. The condition of the fish in the tank was observed frequently and dead fish was removed immediately from the tank. Relevant parameters like pH, DO and salinity were monitored.

Sea water was collected from a clean area off Bombay and brought to the laboratory in polyethylene carboys. After storing for about a week it was decanted, filtered and aerated before use. Continuous aeration was maintained throughout the experiment to keep the DO content above 5mg.l^{-1} .

Different types of effluents from various industries had been collected either directly from the effluent channel or prepared as per the given specification. Tests were conducted on various concentrations of the waste in sea water. In static bioassay tests simulating the given levels of BOD and COD for the synthetic effluent is not possible and hence these parameters were not considered.

RESULTS

Toxicity tests using the waste water were conducted for evaluating LC₁₀ for 96hr. The test decided the concentration of the effluent in sea water at which 90% of the fishes survived in various types of effluents. The nature of effluents varied considerably and are listed separately for evaluating the toxicity.

Effluent from soda ash factories

a) Effluent was obtained from an integrated chemical complex producing soda ash, sodium carbonate, caustic soda, benzene hexachloride, vacuum salt, bromine and pure salt. The industrial

waste generated by this factory contains very high levels of suspended solids which are assumed to be mainly inorganic in nature. The plant takes seawater for cooling from open coast and the waste is released into a nearby channel. The characteristics of the effluent indicate a pH of 10, ammonical nitrogen of 16mg.l^{-1} and suspended solids of $52,684\text{mg.l}^{-1}$.

The salinity of the sea water used for the test was $34.5-35.6 \times 10^{-3}$. The respective ranges of pH and DO during the experiment were 8-8.2 and $6-7\text{mg.l}^{-1}$.

Effluent was collected from the pipe line at the outfall in October 1981. The effluent was turbid and muddy-white in colour. The recorded pH and halide content of the effluent at the time of the experiment was 11 and 94.9g.l^{-1} respectively. In 100% all fishes died immediately. At 75% dilution *T. jarbua* died within 2 minutes while at 50% dilution none survived after 6 minutes. After 1-2hr. all the fishes died at a concentration of 25%. LC10 was observed approximately at a dilution of 9.5% (Fig.1-a).

b) Waste water from another integrated complex for the manufacture of soda ash and related products was tested. This plant's intake of sea water for cooling is also from the open coast about 1.5km south of the effluent release point. The waste water is diluted about 15 times with sea water prior to release to the sea through an open channel. The given characteristics of the effluent indicate an average pH of 8.8 and suspended solids of 2500mg.l^{-1} .

Two sets of samples were tested one before dilution (Effluent No.1) and the other after dilution from the outfall opening of the channel (Effluent No.2). The experiment was conducted in July 1982. The salinity of sea water used for the experiment varied from $35.73-36.24 \times 10^{-3}$. pH and DO variations during the experiments were within the range of 7.9 to 8.1 and $5.5-6.5\text{mg.l}^{-1}$ respectively.

Effluent No.1

The effluent was highly turbid and muddy-white in colour. The recorded pH and halide content of the effluent at the time of experiment, were 10.81 and 102.84g.l^{-1} respectively. In 30% concentration all the fishes were dead within 5 minutes. At 20% concentration also the fishes did not survive for more than 15 minutes. A 7% concentration having salinity more than 40×10^{-3} was also found to be very toxic. LC10 was obtained approximately at a concentration of 5.5% (Fig.1-b).

Effluent No.2

The colour of the effluent was white. It was quite turbid. The pH and halide content of the effluent were respectively 9.5 and 22.7g.l^{-1} . Suspended load was very high and often it was very difficult to observe the fish during experiment. In 100% effluent, the fishes died within one hour. At 85-90% concentration all the fishes died after 2-3 hours. 96hr LC10 was observed at 75% concentration. LC10 obtained for the fifteen times diluted effluent (No.2) was almost proportional to the toxicity observed for the 100 per cent effluent (No.1). It appears that the pH, high halide content and high suspended load influence the survival rate of fish. Thus although the wastewater is diluted 15 times with seawater prior to release in the coastal water, it is still harmful to marine life.

c) A huge soda ash plant being set up, will produce when fully operational around 1200 tonnes of soda ash per day. The process waste will mainly contain high concentrations of sodium chloride, calcium chloride and insoluble calcareous suspended material. The waste stream will have chloride, oxides of metals and carbonate at an approximate concentration of 74.1, 6.4 and 2.3g.l^{-1} respectively. The artificial effluent was prepared based on the effluent characteristics data provided by the firm and the required quantity was prepared fresh each time. The experiment was conducted during April-June 1985. The salinity of sea water used for the tests showed a range of $35.84-36.25 \times 10^{-3}$. DO and pH varied at a rate of $5.5-7.0\text{mg.l}^{-1}$ and 8.0-8.2 respectively. The effluent was pinkish brown in colour with a halide content of 66.48g.l^{-1} . The tested concentration of the artificial effluent varied from 1 to 100%. The suspended load of the effluent settled down within a few hours. Mortality rate was high at higher concentration ranged from 50 to 100% where all the fish died within fifteen minutes. 90% survival for 96hr was obtained at 7% concentration (Fig.1-c).

Synthetic effluent of a fertilizer plant

A giant fertilizer complex aspiring to produce about 6,80,000 tonnes of urea nitrogen per annum was commissioned recently. The synthetic effluent was prepared as per the given specification as the factory did not start functioning when the experiment was conducted in March 1983. The major contaminants are metals like Zn, Cu, Ni, Pb, Hg and urea. However, concentration of all these come within the permissible levels stipulated by Pollution Control Board.

The salinity of sea water used was around 35.4×10^{-3} . A wide range of concentrations were tried. Eventhough the specifications of the effluent did not indicate any toxicity, the cumu-

lative effect appeared to be lethal even at 50% concentration. 90% survival for 96hr was observed at a concentration of 35% (Fig.1-d).

Synthetic effluent of a gas fractionation plant

A plant is being set up for processing of offshore gas rich invaluable fractions of LPG, C₂/C₃/C₄ etc. This plant will generate 3600 m³/d of liquid waste which is proposed to be disposed suitably in the nearby coastal environment.

The experiments were done during January-February 1985. The artificial effluent was prepared as per the given specification. The major toxic substances in the effluents are Pb, Cd, Cu, Zn, Hg, Phenolics, oil & grease. However, the concentration of these have been kept within the permissible level.

During the test the range in salinity, DO and pH were respectively 34.24-35.43x10⁻³, 5.5-7.0mg.l⁻¹ and 7.5-8.0. Tested concentrations of the artificial effluent varied from 25 to 100%. 100% survival of *T. jarbua* was observed upto a concentration of 75%. 90% survival for 96hr was obtained at a range of 85-90% concentration (Table I).

Refinery effluent

A petroleum corporation using sea water as a cooling medium in condensers/coolers which after recovery of oil is discharged back to the sea as an effluent. They have two types of effluent namely Lube Refinery (LB) and Fuels Refinery (FR). The retained fraction of oil in both the effluents is only 14-15ppm while the BOD amounts to 75-92mg.l⁻¹. The typical effluent quality provided indicates that the different constituents stick to the permissible levels. Basically there was not much difference between the two types of effluents. The effluents were collected seven times and the period of study extended from January-June 1984.

The effluent was collected from the discharge points at intervals of 2-3hr for 24hr to get a representative sample. The effluent once obtained was used only for about 10 days and again a fresh set was obtained. A total of seven series of experiments were done. During the experiment salinity, DO and pH ranged at the rate of 33.4-35.2x10⁻³, 5.5-7.2mg.l⁻¹ and 7.9-8.1 respectively.

Observed toxicity indicated wide variations. A log-dose response was analysed by probit analysis for all 7 samples. Survival rates of 90% for 96hr was then calculated for all the samples (Table II). Due to non-availability of sample, it

was not possible to calculate the value for two samples.

There was conspicuous variability in the toxicity of the two types of effluents tested indicating difference in the nature of the waste water. In general, FR appeared to be less toxic than LR. The observed variation in the toxicity of FR was relatively limited.

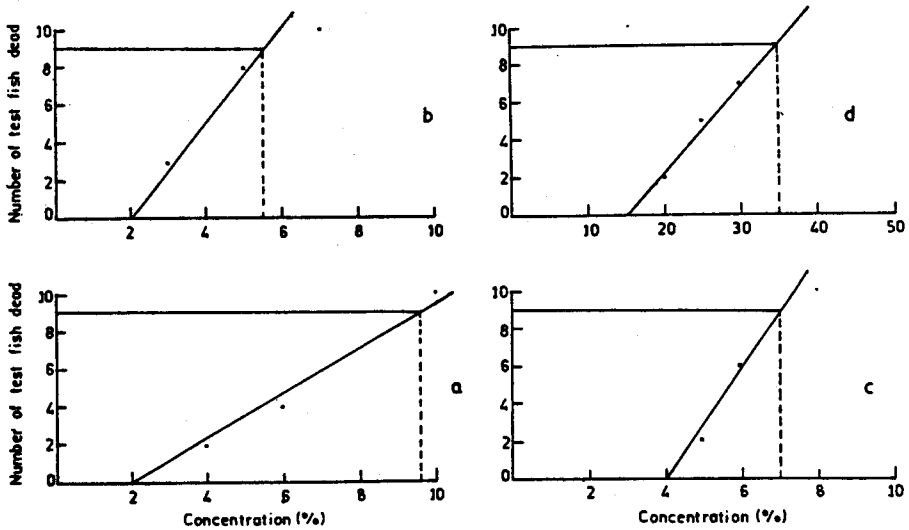


Fig.1. Mortality rate of *T.jarbua* at different concentrations of effluents from soda ash factories (a,b,c) and fertilizer plant (d).

Table I - Survival rate of *T.jarbua* at different concentrations of the artificial effluent of a gas fractionation plant.

Concentration (%)	Percentage survival			
	24 hr	48 hr	72 hr	96 hr
NIL (Control)	100	100	100	100
25	100	100	100	100
50	100	100	100	100
75	100	100	100	100
85	100	100	95	90
90	100	100	90	90
95	100	100	90	80
100	100	90	90	80

Table II - Calculated concentration of the refinery effluent for 90% survival of *T.jarbua* for 96 hr.

Date	Lube Refinery	Fuels Refinery
25.1.84	32.73	xx
06.2.84	28.64	100
23.2.84	65.61	++
07.3.84	40.70	xx
13.3.84	30.20	58.21
12.5.84	xx	++
14.5.84	57.54	57.54

xx 100% survival at 100% concentration at 96 hours

++ Sample got over after the test at 60% concentration

DISCUSSION

The advantage of toxicity testing is to measure the actual toxicity of complex waste streams generated by different industries. In the present study different types of effluents were tested of which a few are synthetic effluents. During the construction of a plant a synthetic effluent certainly serves as a tool to measure the toxicity of the actual effluent which would be generated after commissioning of the plant. This will help in the suitable design of the effluent discharge system.

Among the different types of effluent studied, the wastes from soda ash factories were found to be more toxic than the other effluents. The results on toxicity of the three types of effluent from the soda ash plants indicate comparable values. The effluent toxicity of the soda ash plant is mainly due to the very high chloride content and suspended load. The deleterious effects of suspended load to fish is mainly due to clogging of the grills with particles leading to asphyxiation of the fish¹⁰ and turbidity which will reduce the activity of the fish¹¹.

Effluent from the fertilizer plant is toxic giving an LC10 of 35%. Toxicity of another fertilizer effluent was reported to be harmful even at 25% dilution⁵. Fertilizer factory effluent is rich in nitrogenous waste. Again, ammonia present in the fertilizer effluent is reported to be highly toxic for marine organisms³. Toxicity of ammonia is largely attributed to the undissociated base (NH_3) which has a penetrating property rather than to ammonium ion (NH_4^+) which cannot pass through the tissue⁵. Effect of ammonia is on the impairment of physical

stamina, suppression of growth and lowering of disease resistance¹². Urea which usually is a component of fertilizer effluent may not directly kill the fish⁴. Both nitrite and nitrate which are the oxidative products of ammonia are found in high concentration in the fertilizer effluent. High concentrations of nitrite may pose potential danger to fish as it oxidises haemoglobin to meta-haemoglobin which can not combine with oxygen leading to the formation of anoxia.

The effluent from a gas fractionation plant or a refinery is expected to contain oil, grease and phenolics. In the case of petroleum, the most obvious effects are due to its hydrophobic nature and its impermeability to oxygen. Thus when it coats organisms, they die from asphyxiation. The harmful effect of all on living organisms is either physical or chemical. Since many of the components of oil are chemically stable and not readily metabolised or excreted, once absorbed they are subjected to food chain amplification giving either unpleasant flavour to food for human consumption or render it toxic.¹³

The objective of acute toxicity testing of waste materials to marine organisms is to evaluate the degree of dilution and dispersion needed to render the waste harmless. The customary method is to conduct a bioassay test, generally for 96hr to determine the concentration which will kill 10% of the total population of test organisms in that period of time. As the toxicity differs depending on the test organism, choice of the most sensitive animal can give more reliable information. The technical difficulty in applying bioassay results to dumping waste is that organisms in the sea are not exposed to a fixed concentration, but on the other hand to a constantly decreasing concentration due to natural mixing/dilution process in the sea. Tests to simulate similar conditions in the laboratory is very difficult to achieve and maintain. However, as a general rule the concentration found to be toxic in a 96hr bioassay test can be considered as the maximum allowable concentration at the disposal site one hour after discharge¹. This again will have its own limitation if the discharge is continuous and will depend mainly on the physical properties of receiving system. The dilution/dispersion characteristics of the body coupled with the 96hr LC10 value could help in selecting the maximum allowable concentration. This calls for the incorporation of toxicity testing as part of all the environmental monitoring studies related to waste disposal.

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