1.1 The Problem

Assam, the North Eastern province of India, is the habitat of several endangered species of avifauna. Out of the total 950 species and sub species of avifauna found in Assam, almost 100 came under different kinds of threat. Moreover, out of 78 species of birds of Red Data Book, in India as many as 45 species are found in Assam (Islam et.al, 2003).

It has been noticed that population of some of the species is gradually declining in Assam without any visible cause and habitat degradation. Some of the agro-land and wetland based avifauna are becoming threatened with local extinction and showing decline in population.

Studies on some environmental stresses on two species of storks
However, the Brahmaputra Valley of Assam is well known for the habitat of world’s most endangered species of stork, the *Leptoptilos dubius*. Earlier, it was common in Northern India, Nepal Terai, Bangladesh, Burma, Thailand, Laos, Vietnam and Cambodia. The Bird Life International (BLI) stork specialist group network reported that the species is systematically disappeared from almost throughout the former distribution range (Luthin, 1987). The recent report about *L.dubius* breeding colony is from Assam and Cambodia only (Saikia and Bhattacharjee, 1989; Mundkur et al., 1995). The nesting of birds is extremely localized in few ecological pockets of the Brahmaputra Valley of Assam. It was reported that in Assam there were nesting mortality of *L.dubius*, caused by unknown causes (Saikia and Bhattacharjee, 1989, 1990).

The contemporary literature exposed that several fish eating and carnivorous bird species are affected by organ chlorine pesticides and heavy metals which results in reduction of eggshell weight and thinning of eggs shells which leads to eggshell breakage and reproductive failure.

But there is no study what so ever on the effect of the environmental pollutions like the heavy metals on the eggs of the common as well as the endangered species in Assam, while steps by habitat manipulation and stork physical protection is being taken by NGOs and wildlife biologist to protect the endangered species.

*Studies on some environmental stresses on two species of storks*
The study, therefore, is undertaken with a view to reveal the relationship of environmental pollution i.e., heavy metal pollution with declining population of \textit{L.dubius} along with \textit{L.javanicus}, to compare the impact of heavy metals at species level.

1.2 Heavy Metals

Heavy metals are the metallic chemical elements those have a relatively high density and are toxic at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), and lead (Pb). Heavy metals are natural substances, but human activity has lead to abnormal release of them and accumulation in the environment. Some metals are essential for organisms (or for specific species), but metal toxicity is usually a result of exposure to high levels of non-essential metals, for example cadmium (Cd) and mercury (Hg). Metals are not biodegradable, and therefore they are not transformed to less toxic forms in an organism. In higher organisms, the system for handling nonessential metals includes binding to specific proteins (called metallothionein) or storing them in intracellular granules. The first solution shields the metals toxic properties, and the second method produce insoluble forms of the metal for long-term storage or excretion. If they are not excreted, some metals can bio-accumulate in tissues, especially in top predators (Gross et. al, 2000).

Mercury (Hg) is one of the heavy metals found in elevated concentrations in the environment. Mercury is used in industry, including battery, paper, paint,
chemicals, agriculture, dentistry and medicine. Burning of coal, natural gas, and refining of petroleum products adds 5000 tons mercury per year to the atmosphere. Mercury enters the aquatic environment either by atmospheric deposition or from direct discharge of wastes containing mercuriferous. If mercury is methylated to methyl mercury (MeHg), it is rapidly bioaccumulated by aquatic organisms, and this compound is much more toxic than the inorganic form of mercury (Gross et al 20). The biological half time of mercury is long, and they bioaccumulate in the food chain.

High concentrations of mercury have been associated with developmental and behavioral abnormalities, impaired reproduction and survival, and in some cases with direct mortality. There is evidence that mercury may act synergistically with organic pollutants such as PCBs (Gochfeld 1975).

**Lead (Pb)** is a heavy metal. It is a non-essential toxic metal that affect all body systems (Gross et al 2000). Lead in the environment arises from both natural and anthropogenic sources. Road side soils also have long been known to contain high levels of heavy metals, specially lead (Pb). High value of Pb can be attributed to anthropogenic effects related to motor vehicles. The contaminated roadside soils can cause health hazard to the organisms if the metals are transferred to the near by water bodies. Lead has significant anthropogenic enrichment and water bodies can wash into the contaminated soil particles near where they form a potential source for bioaccumulation of lead (Southerland and Tolosa 2001).

*Studies on some environmental stresses on two species of storks*
Cadmium (Cd) is a by-product of copper, zinc and lead mining. It is also found in industrial sludge and in phosphate fertilizers (Gross et al 2000) and used in rechargeable nickel-cadmium batteries and as surface treatment of some product types (Miljøstatus Norge: Kadmium). Other sources for emission are waste incineration and fossil fuel combustion (AMAP Assessment Report (2)). Cadmium is toxic to most life forms, and chronic effects are seen after relatively low doses in many species. It is taken up directly from water or to some extent via food and air. Cadmium bioaccumulates, if the intake of cadmium is greater than what the body can handle, it can lead to kidney damage and interfere with the vitamin D and calcium metabolism.

Nickel (Ni) is another heavy metal. It is needed in small amount by animal body to produce red blood cells, however, in excessive amount, can become mildly toxic. Nickel can accumulate in aquatic life, but its presence is not magnified along food chain.

1.3 Objectives

In and around Sivasagar, there are more than 200 of oil rigs, closely spaced Group Gathering Station (GGS), Oil Collecting Station (OCS), associated with oil-fields of Oil and Natural Gas Company Limited (ONGCL), create environmental hazards in the locality by polluting water bodies in their vicinity by effluents, oil sledges and by continuous burning of natural gases (Bhagabati, R. 1998). The release of effluents into nearby fresh water bodies make it polluted which is fully loaded with oil sludge and

Studies on some environmental stresses on two species of storks
grease. The effluents of oil sludge from oil fields affect the agro-land nearby and affect the aquatic life indirectly, thus affecting all life forms (Manahan, 1979). The effluents from the oil fields are the sources of heavy metals like Hg, Pb, Cd, Zn, Cr, Cu and others that come from components of both drilling fluids and drilling cuttings (Patin, 1990).

Heavy metals are natural components of the earth's crust. They cannot be degraded or destroyed. To a small extent they enter animal's body via food chain, water and air. As trace elements, some heavy metals viz. Zn, Se, Cd etc., is essential to maintain the body metabolism. But at higher concentrations they can lead into poisoning. Heavy metals are dangerous, as they tend to bioaccumulate. Compounds accumulate in living things anytime they are taken up and stored faster then they are broken down (metabolized) or excreted.

However, birds accumulate high concentration of toxic metals (Burgher and Gochfeld, 1985), as they are on the higher trophic level at their respective food chain, mainly the fish eating and other carnivorous bird species.

Early in the 1970s, several authors (Gochfeld, 1971; Rappe, 1973) pointed out that birds are at the top of the trophic level and represent an early warning system (Hays and Risebrough, 1971) for mercury and other pollutants.

Studies on some environmental stresses on two species of storks
The eggshell of birds by virtue of its structure and composition is essential for the propagation and ultimate survival of avian species. The calcareous eggshell protects the developing embryo from environmental stresses. It is designed to resist external physical forces viz., the weight of an incubating adult. Moreover, the eggshell is also designed to protect from microbial penetration and dehydration of the embryo and to provide Calcium and protein for the developing skeleton (Romanoff, 1967).

Hence, it is aimed to investigate the oil-field pollution i.e., heavy metal pollution, related to environmental stress on the eggs of the wetland bird species. To establish the hypothesis the following objectives for the study has been taken;

1. To evaluate the composition of the eggshell structure of one endangered and one threatened species for comparison of the impact of heavy metal at species level.

2. The evaluation of the status of the elements in the eggshell.

3. To assess the damage at the structure and the ultra-structure level of the eggs.

*Studies on some environmental stresses on two species of storks*
A pair of Greater Adjutant stork (*Leptoptilos dubius*) on a nesting tree

A single Greater Adjutant stork (*Leptoptilos dubius*)
An adult Lesser Adjutant stork (*L.javanicus*)

A juvenile Lesser Adjutant stork (*L.javanicus*)

A pair of Lesser Adjutant stork (*L.javanicus*)

A Lesser Adjutant stork (*L.javanicus*) in flight