# A SATELLITE IMAGERY AND GIS BASED STUDY ON THE URBANIZATION AND THE POLLUTION OF THE OUSSUDU LAKE AS INDICATED BY AQUATIC WEED INFESTATION

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## ABSTRACT

The most evident, dramatic, and conclusive evidence of the gross pollution of any lake due to urbanization is provided by aquatic weeds. Whereas industrial pollution may or may not add plant nutrients to a lake, demographic pressure almost always does. The resulting excessive supply of nutrients enables the invasive plants to thrive and colonise the lake. Such colonization can provide almost graphic evidence of the severity of demographic pollution of a lake.

In this paper we present a study of Oussudu lake which is the largest freshwater lake of Pondicherry as also a heritage site. We have conducted an assessment of the area covered by the amphibious weed *Ipomoea carnia* using the satellite imagery IRS – ID LISS III in conjunction with GIS. The infestation by submersed weeds was simultaneously studied by ground truth studies. The weed biomass density in each case was estimated at 5 sampling stations by biomass harvest method.

The study reveals that almost a fifth of the lake area has been colonised by *Ipomoea*. The rest of the lake is heavily infested by submersed weeds, principally *Ceratophyllum* and *Hydrilla*. The implications of these findings and the measures necessary to reverse the trend of the demographic pollution of Oussudu are discussed in the paper

## STUDY AREA

The Oussudu watershed is situated at 11°57' North and 77°45' East, on either side of the border separating Pondicherry and Tamil Nadu (Figure 1). Apart from playing a crucial role in recharging the ground water aquifers, the Oussudu watershed also harbors rich flora and fauna. This watershed supports Pondicherry's largest inland lake - Ousteri (Tamil for *Oussudu - eri* , also called Oussudu lake) with a surface area of 8.026 $Km^2$ and shoreline length of 14.71 $Km^2$. Oussudu lake is such an important wintering ground for migratory birds that it has been identified as one of the heritage sites by IUCN (International Union for Conservation of Nature) and has been ranked among the most important wetlands of Asia (Scott 1989).

In the recent past, Oussudu lake and its watershed have been subject to enormous pressures due to the increasing population, industrialization and urbanization.

## METHODOLOGY

### Biomass Estimation

The biomass estimation was done using the total harvest method as per APHA (1998). Brass rings with 31 cm diameter and 0.5m length, were used as a sampling unit. These rings were placed at 5 representative sites (Figure 2). Once the rings were placed, all the macrophytes that were within the circumference of the rings were harvested, segregated, identified, packed in polythene covers and labeled appropriately. Some of the samples included grossly decayed plant material which had become unidentifiable. Such biomass was recorded as 'mixed phytomass'.

The samples were washed under the running tap to remove the debris and silt and were placed in a cloth bag. To this bag a piece of strong thread was tied and swirled till all the excess water had been removed by the centrifugal force due to the swirling action. At this point the samples were weighted for the *'fresh weight'*, also called the *'wet weight'*. The samples were then oven dried at 105 $^{0}$C to a constant weight, and referred as *'dry weight'*.

The moisture content has been calculated as follows:

$$\text{Moisture, \%} = \frac{\text{(Fresh weight - dry weight) X 100)}}{\text{Fresh weight}}$$

### Remote Sensing and GIS

The area covered by *Ipomoea* was estimated using remote sensing and GIS. The satellite imagery, IRS-ID LISS III, dated 27 Aug 1998, was processed using the image processing software - *Image Analyst 8.2* and the GIS software *MapInfo Professional 5.5*. The image was later classified for the land cover / land use categories as per the system adopted from Avery and Berline (1992). The classified image was interpreted by means of visual observation and later substantiated by the post field training areas (on-site verification).

## RESULTS AND DISCUSSION

Oussudu lake was found to be heavily infested with *Ceratophyllum demersum* and *Hydrilla verticillata* – two of the world's most dominant submersed weeds. The weeds form such dense mats in some parts of the lake that it is impossible to cast dragnets for capturing fishes there (Chari and Abbasi, inpress).

The species, *Ceratophyllum,* was the most widespread and present at all the sites (Table 1, Figure 3). The fresh weight of this species varied between 268 g $m^{-2}$ and 2576 g $m^{-2}$, with an average of 999 g $m^{-2}$. The dry weight varied between 31 g $m^{-2}$ and 317 g $m^{-2}$, with an average of 122 g $m^{-2}$ (Table 2, Figure 4a). The moisture content, with respect to fresh weight, varied between 89.4% and 87.67%, with an average of 88.1% (Table 2, Figure 4a).

Like *Ranuncules*, *Nymphea*, and *Vallisneria, Ceratophyllum* is known to precipitate lime. Also, this species is capable of utilizing bicarbonate ions as a source of carbon (Gupta, 1987).

The other aquatic weed, *Hydrilla verticillata,* was found at the sites M1 and M2 (Table 1, and Figure 3). The fresh weight of the species varied between 5 g $m^{-2}$ and 676 g $m^{-2}$, with an average of 340 g $m^{-2}$. The dry weight varied between 0.75 g $m^{-2}$ and 74 g $m^{-2}$, with an average of 37 g $m^{-2}$ (Table 2, and Figure 4a). The moisture content, with respect to fresh weight, varied between 85.6% and 89.07%, with an average of 87.3% (Table 2, and Figure 4a).

*Hydrilla,* due to its low light compensation, 10 -12 Einsteins $m^{-2}$ $sec^{-1}$, is known to grow even at depths where no other plant life is known to occur in the aquatic habitats (Gupta, 1987). Hence, the spread of *Hydrilla* showed a positive correlation with the water depth of the lake (Figure 4b).

The mixed phytomass sample collected at site M3, weighed 555 g $m^{-2}$ when fresh, and 61 g $m^{-2}$, when oven-dried. The moisture content measured 89% of the fresh weight (Table 2, Figure 4a).

According to the remote sensing and GIS studies carried out, *Ipomoea* covered 1.16 $Km^2$, which is 14% of the land-cover of Oussudu lake.

The presence of rampaging mats of terrestrial and aquatic weeds in Oussudu indicates that the lake is highly polluted and is, as a result, becoming eutrophic or 'obese' (Abbasi, 1997; Chari, 1997, 1998; Plate 1).

Colonization of aquatic weeds can upset the ecosystem in several ways. A few of them are mentioned below.

(i) The thick mats of the weeds prevent sunlight from reaching the submerged flora and fauna, thereby cutting off their energy sources and disturbing the ecosystem.

(ii) Once weeds colonize a water body due to pollution, they deteriorate the water quality further (Abbasi and Nipaney, 1993). The decaying of these weeds adds to the depletion of dissolved oxygen, and increase the BOD, COD, nitrogen and phosphorus, apart from encouraging the growth of various pathogens which may be harmful to humans.

(iii) The spread of weeds in the lake reduces the area available to fishes and hinders their mobility. The depletion of dissolved oxygen may result in mass fish kills or may favor only certain kinds of fishes, which can tolerate low oxygen levels.

(iv) The profuse growth of weeds breaks natural water currents. As a result, the water becomes stagnant, favoring the breeding of mosquitoes and other disease causing vectors

(v) Aquatic weeds are known to carry plant pathogens, which infect several crops and some of them even affect humans. The extracts of fresh / decaying leaves and rhizomes of aquatic weeds are known for phytotoxicity (Abbasi, 1997).

(vi) Weeds provide ideal habitat for the growth of molluscs, which in turn choke water supply systems (canals and pipes) and impart undesirable taste and odour to water. Mollusks such as snails, are primary hosts to blood and liver flukes – the human disease causing pathogens. These mollusks seek shelter, multiply, and find sustenance among the roots of the weeds.

## RECOMMENDATIONS

The control of aquatic macrophytes is essential to restore the water quality and general health of a lake. Several methods of controlling the aquatic macrophytes have been suggested and field-tested for their effectiveness (Table 3). Of these methods, the one based on weed foraging by the diploid grass carp (*Ctenopharyngdon idella,* white amur) is the most effective at controlling the growth of aquatic macrophytes and filamentous algae (Cooke et. al., 1996). Hence, using the grass carp would not only control the aquatic weeds but also the filamentous algae of Oussudu lake.

The species - *C.idella* - was earlier introduced by the Department of Fisheries (Pondicherry) in Oussudu lake, but is no longer present now. The triploid variant of this species, which is genetically derived from the diploid grass carp, would preclude any possibility of the spread of the species.

Apart from *C. idella, Tilapia zilli* and *Tilapia aurea* also feed voraciously on the macrophytes and the filamentous algae.

## ACKNOWLEDGEMENT

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**Table 1. The details of the biomass harvest method for the macrophytes of Oussudu lake at various sampling spots.**

| Site | Depth (m) | Seechi (m) | Macrophyte | Fresh wt g $m^{-2}$ | Dry wt g $m^{-2}$ | Moisture content (%) |
|---|---|---|---|---|---|---|
| M1 | 0.48 | 0.34 | Ceratophyllum sp. | 2576 | 317 | 87.7% |
| | | | Hydrilla sp. | 5 | 1 | 85.6% |
| M2 | 0.62 | 0.59 | Ceratophyllum sp. | 268 | 31 | 88.4% |
| | | | Hydrilla sp. | 676 | 74 | 89.1% |
| M3 | 0.29 | -- | Ceratophyllum sp. | 864 | 97 | 88.7% |
| | | | Mixed phytomass | 555 | 61 | 89.1% |
| M4 | 0.45 | 0.39 | Ceratophyllum sp. | 439 | 47 | 89.4% |
| M5 | 0.06 | -- | Ceratophyllum sp. | 849 | 117 | 86.2% |

**Table 2. The average fresh weight, dry weight and moisture content of the macrophytes of Oussudu lake.**

| Macrophyte | Average Fresh wt (g $m^{-2}$) | Average dry wt (g $m^{-2}$) | Avg moisture content (%) |
|---|---|---|---|
| *Ceratophyllum sp.* | 999 | 122 | 88.1 |
| *Hydrilla sp.* | 340 | 38 | 87.3 |
| Mixed phytomass | 555 | 61 | 89.1 |

**Table 3. Comparison of lake restoration and management techniques for control of nuisance aquatic weeds (source: Olem and Flock, 1990)**

| Treatment (one application) | Short-term effectiveness | Long-term effectiveness | Cost | Chance of negative effects |
|---|---|---|---|---|
| Sediment removal | E | E | P | F |
| Drawdown of water | G | F | E | F |
| Sediment covers | E | F | P | L |
| Grass Carp | P | E | E | F |
| Insects | P | G | E | L |
| Harvesting | E | F | F | F |
| Herbicides | E | P | F | H |

E = Excellent; F= Fair; G= Good; P= Poor; H= High; and L= Low

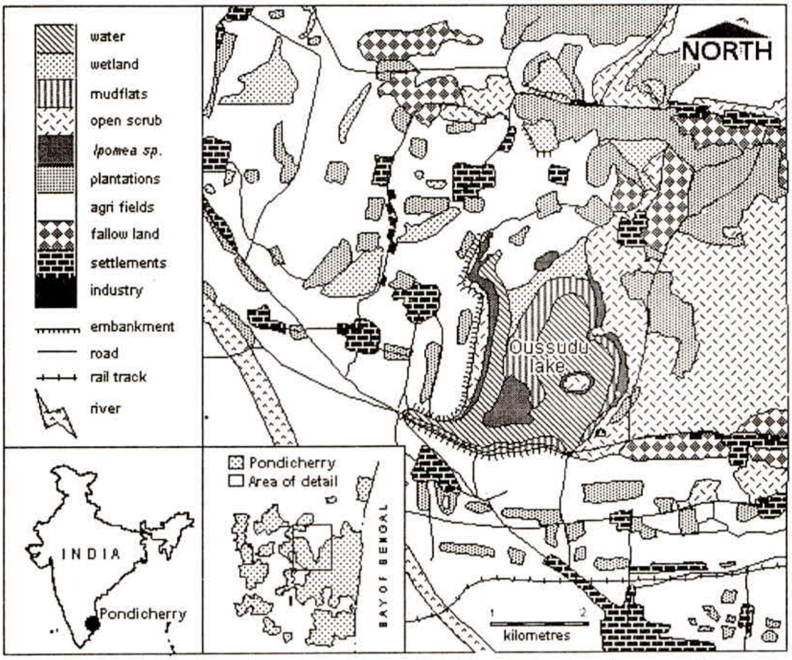



**Fig. 1. Location and land use / land cover of the Oussudu catchment during summer**


**Figure 2 Location of the sampling stations (M1, M2, M3, M4, M5) selected for estimating the biomass of the macrophytes**

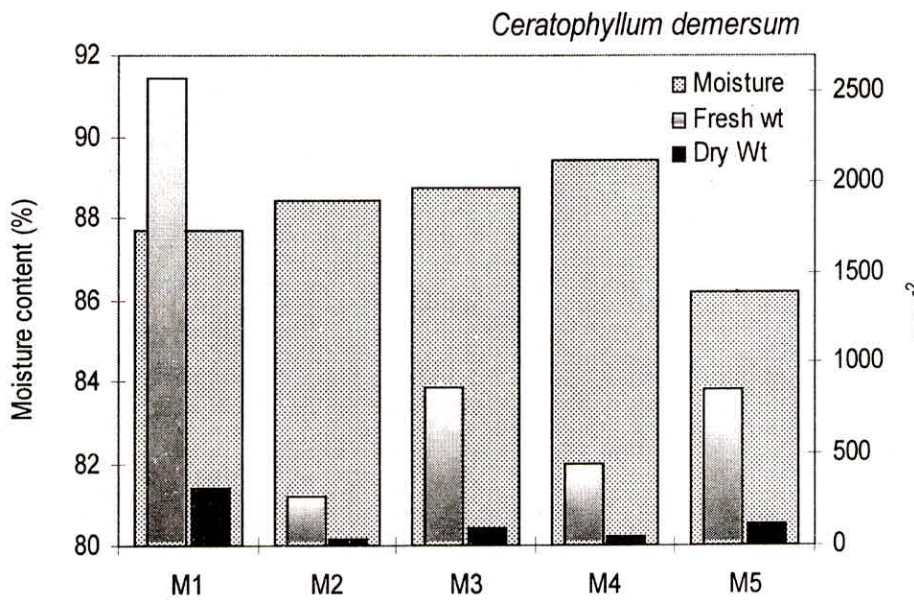
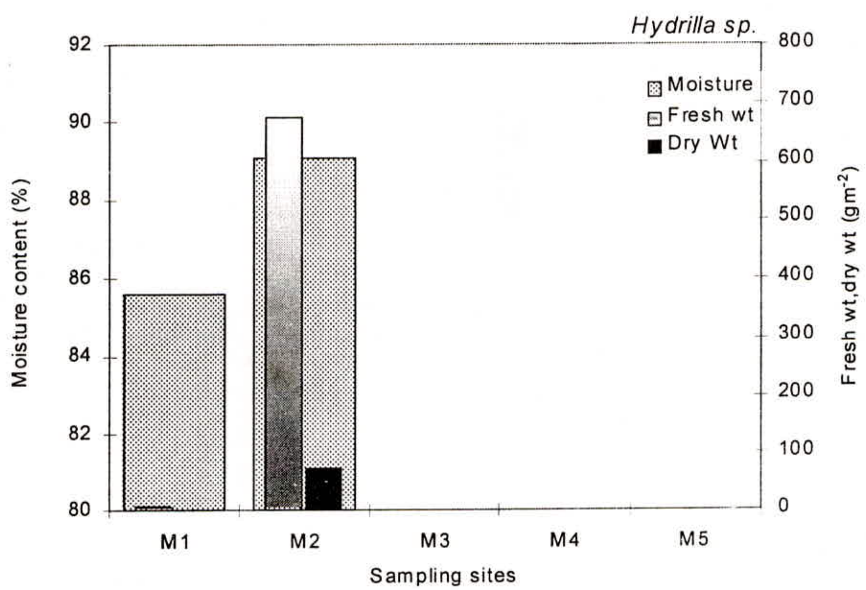
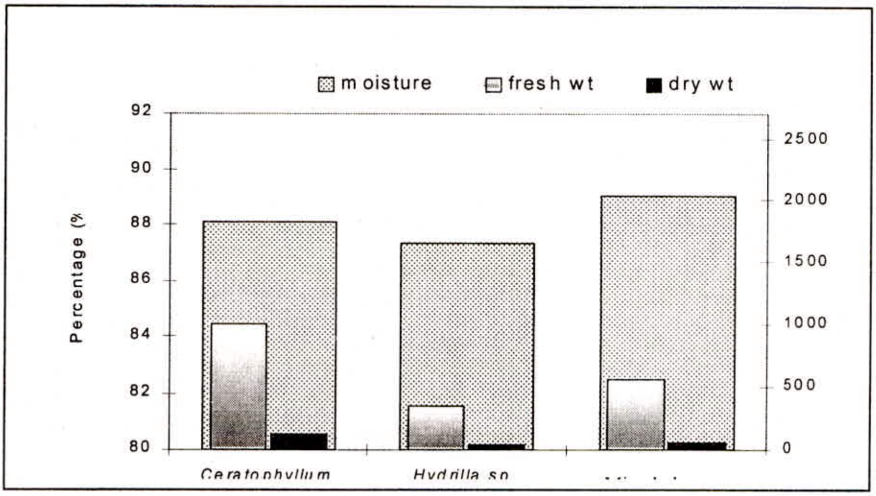



**Figure 3** The distribution of the macrophytes, *Ceratophyllum sp.* and *Hydrilla sp.*, at various sites





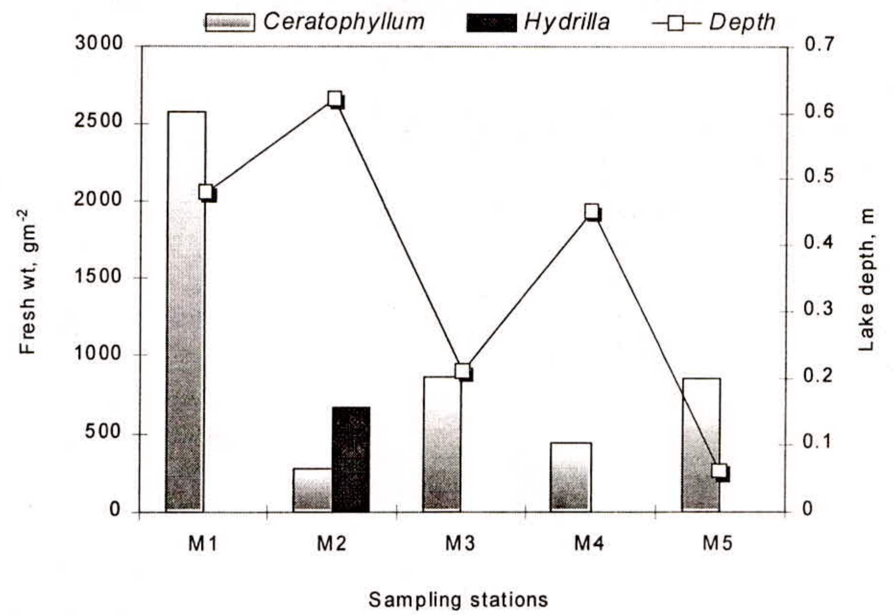




**Figure 4** (a) the average fresh weight, dry weight and moisture content of the macrophytes (b) The distribution of macrophytes at various sites and the lake water depth

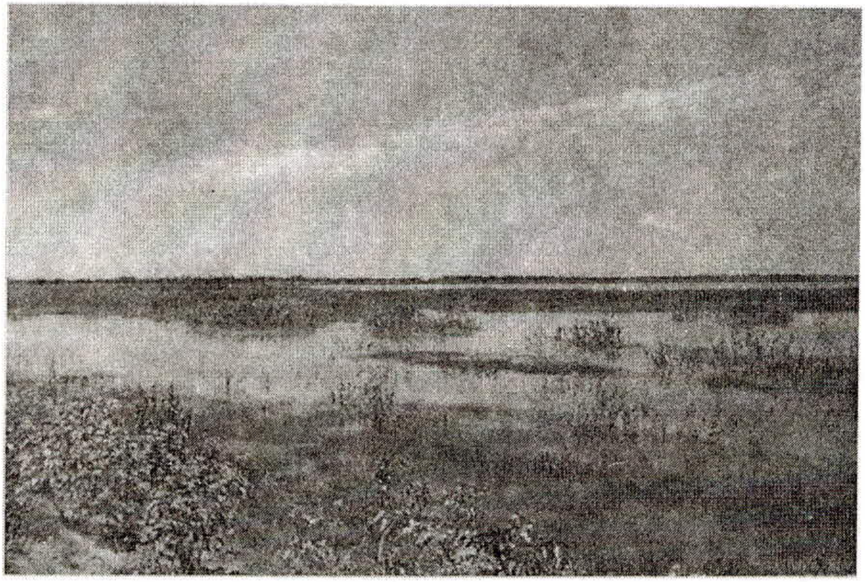


**Plate 1 The rampant spread of *Ipomoea sp.* in Oussudu lake (above and below)**
**(Coloured photograph is given at the end of the book)**