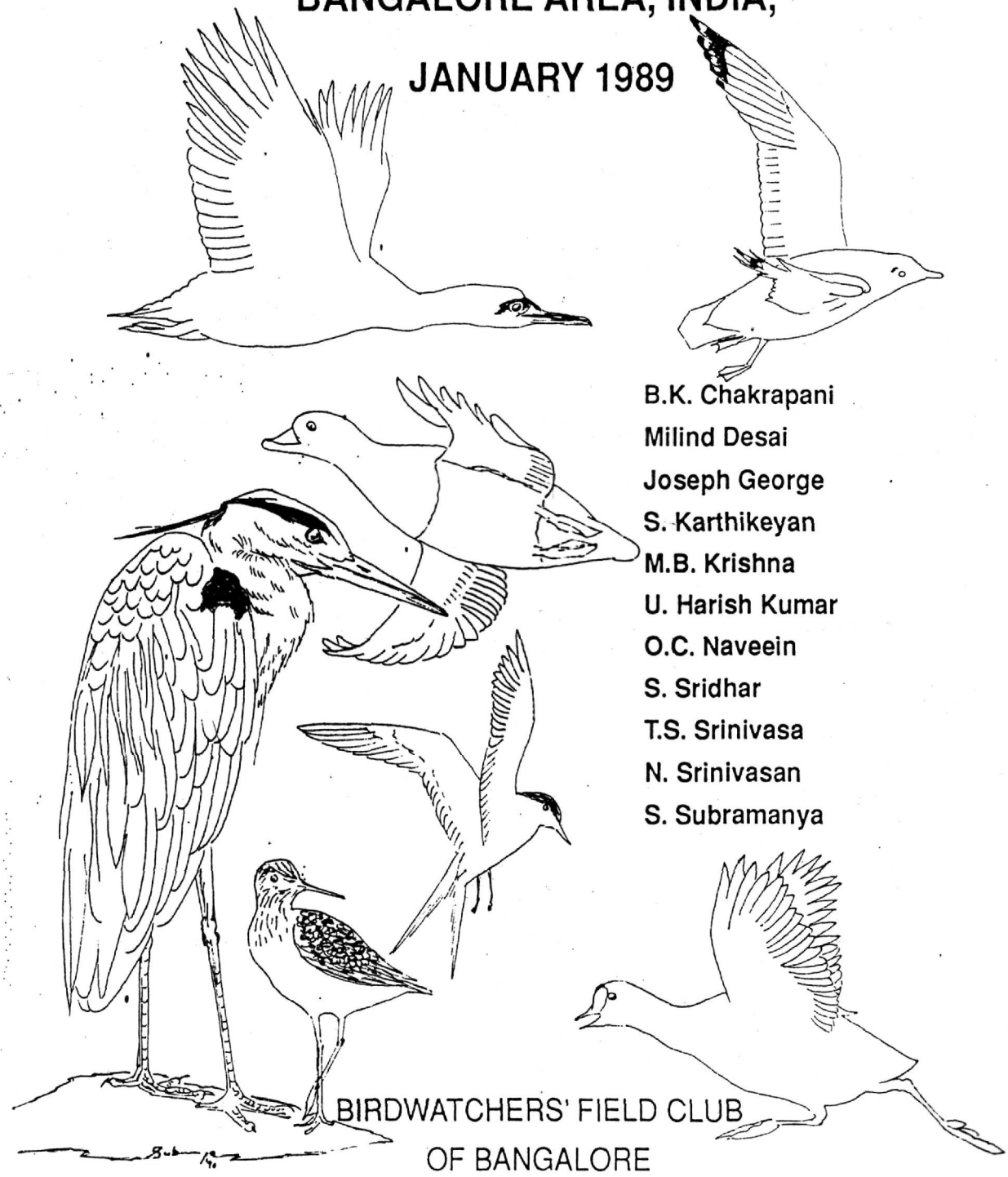
SURVEY OF IRRIGATION TANKS AS WETLAND BIRD HABITATS IN THE BANGALORE AREA, INDIA, JANUARY 1989



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BIRDWATCHERS' FIELD CLUB
OF BANGALORE
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(The alphabetical order of names does not indicate, imply or suggest priority, effort put in, or extent of contribution)

Sponsored by the Research &Utilisation Division
Karnataka State Forest Department

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INTRODUCTION

Wetlands are areas marginal between land and water, inundated or saturated frequently enough to support plant and animal communities adapted to a life dominated by water. It encompasses areas of marsh, swamp, standing or flowing water which is fresh, brackish or salty. It also includes areas with marine waters, the depth of which at low tide does not exceed six metres or twenty feet. This definition also includes man made systems and the tanks in and around Bangalore fall into this category.

Freshwater wetlands occupy less than three percent of the land area of the Earth, but are dynamic and highly productive habitats which support vast populations of birds quite out of proportion to their extent. Because of the well established waterfowl-wetland link, waterfowl census is an indispensable tool for the assessment and monitoring of wetland habitats. Apart from their role in serving as biological indicators of the wetlands, waterfowl also serve as a source of aesthetic pleasure. A blending of these two ideas has resulted in thousands of volunteer ornithologists and birdwatchers counting waterfowl during appropriate periods of the year in important wetlands throughout the world. Not only do these counts indicate the health of any given wetland, but they also can provide an insight into waterfowl populations as a whole, their movements and choice of habitats.

The reason for starting the counts in the first place was the growing concern amongst ornithologists and certain hunters at the apparent decline in waterfowl populations. The counts were therefore, designed to provide a positive measure of any changes in wildfowl numbers. The concept was that if regular counts were made at set intervals in a large enough sample of sites, and for a long enough period of years, the true pattern of trends would be bound to emerge. The middle of January has been chosen as the period most likely to produce reliable results since the birds would have completed their autumn migration and would be well established in their winter quarters. This means that the populations are more or less static, which greatly reduces the possibility of the same birds being counted twice. In practice, the census period can safely be stretched to include the week before and after the set period, in order that the number of sample sites be as numerous as possible.

The topography of Bangalore uniquely supported the creation of a large number of tanks (about 389). The establishment of tanks in and around Bangalore, initially served as a source of water for agriculture, drinking and washing purposes. As they aged over the years, they also turned into lentic-closed aquatic habitats and attained an important ecological status.

Tanks, their environs and the variety of life they supported did offer ample scope for recreation and, they were always held in high aesthetic and reverential esteem by the people. This value was further enhanced by presence of welcome greenery in the shore regions.

Partial food needs and economic importance from fishing and other living resources were also served to some extent.

Bangalore has the dubious distinction of being the fastest growing city in India. It had a population of about four million people in 1985 and this figure is estimated to cross seven million in 2001 AD. and the annual rate of increase is estimated to be 5.5% till then (Pani et. al. 1985). With the rapid horizontal growth of the city to accommodate the ever increasing population, more and more agricultural land is being converted for non-agricultural purposes. The tanks, which were essentially intended to impound rain water for agriculture are being engulfed by the growing city. The tanks are being either reclaimed, breached or have sewage let into them. This apathy towards the wetlands is slowly being felt. This attitude has been mainly due to lack of appreciation of the hydrological, ecological, biological and aesthetic values of the wetland at different decision and policy making levels.

Ecological Importance of Tanks

The ecological importance of tanks is wide ranging and multifarious, even extending into the domain of the local socio-economic situation.

Tanks also have a tremendous hydrological role to play. Because they serve as checks against seasonal (monsoon) rapid water flows in valleys, they automatically act as checks against minor floods and more important, drought conditions during dry months. Apart from helping to store large quantities of surface water, they help to recharge ground water. This inturn would help to maintain water yields of the wells and tube wells close by.

These tanks posses both deep water zones and shallow zones of varying extent, and this imparts a unique ecological significance. a) Deep water zones serve to support ducks. b) Shallow water zones and associated soft mud banks and mudflats support waders, herons and other marshland waterfowl.

These tanks are zones where raw materials both new and those derived from the breakdown of dead and decaying plant/animal matter within the system are recycled endlessly, through complex food chains and food webs.

The bird life supported by such tanks further plays an important role in providing raw materials in the form of major nutrients especially nitrogen, potassium, phosphates and other inorganic salts (minor but essential nutrients) directly into the tank water through their droppings. These help to make the tank waters fertile and initiate the food chain from the planktonic levels. This eventually makes the water body highly productive in overall terms. Since a major part of this water is used for irrigation in the rural areas, the already fertile waters would be able to support a higher crop quality.

Waterfowl census

Systematic counts of waterfowl were first taken in England in the latter half of the thirties. The counting lapsed between 1939 and 1947, but were restarted as a nation wide investigation in 1948. Regular winter counts were also started almost at the same time in Netherlands and the Federal Republic of Germany and shortly afterwards in Switzerland. Efforts to carry out such counts in Asia were probably made after the "Convention on Wetlands of International Importance - especially as waterfowl habitat" was drawn up at Ramsar, Iran in 1971. India became a signatory in 1982 and the census as a nation-wide effort in India started in 1987.

Since the inception of this census programme in our country, a group of Bird watchers from Bangalore, has been taking counts of waterfowl in and around the city.

Objectives of the survey

In the light of the background and introductory information provided earlier the most starkly evident observations which the birdwatchers made within a short period of 2 years of census (1987 and 1988) were that the majority of the wetlands (tanks) have been abused almost beyond redemption, hardly managed and the waterfowl populations were being threatened or eased out from their former habitats, hence the survey.

The objectives were to :

1. Survey the diversity and distribution of waterbirds in and around Bangalore in representative wetland habitats.

2. To collect information on the ecological status of the wetlands from as many ecological angles as possible.

3. To make suitable recommendations from the information collected.

CHAPTER I A

Topography of the Bangalore area in relation to the Watershed pattern

The Bangalore area is elevated and plateau-like being about 855 to 940 m above MSL. There extends a ridge from N to S, on the western side dividing the area so as to fall into two basins : the Arkavathi basin on the west and the Dakshina Pinakini on the East. Hence the streams and valley systems essentially extend latitudinally.

There are no natural lakes in the area : all the water bodies are man-made and are essentially impoundments across natural streams which may or may not exist intact today. Those flowing west are few and drain into the nearby Arkavathi river or its tributary, the Vrishabhavathi stream. They are short and reflect the essentially steeper slope of the western side of the ridge. Those flowing East are longer and drain into the Dakshina Pinakini river. Both the rivers flow to join the Kaveri and hence the Bangalore area falls compeletely within the Kaveri basin.

The valley systems exert a strong influence in the distribution of the aquatic flora and fauna - especially plankton.

Most of the tanks in the Bangalore area occur in the Dakshina Pinakini basin. Sixty seven tanks were covered from this basin. From the Arkavathi basin twenty five tanks were covered. In addition five city tanks vix., Lalbagh, Yediyur, Sankey, Ulsoor and the now filled up J.P Nagar tank were covered in the census.

CHAPTER I B

Land use pattern in and around Bangalore

Studies of land use pattern made through remote sensing in 1985 indicate that only 4.8% of the land is covered with water in the Bangalore area(Behera et. al. 1985).

The area covered by water takes a greater importance if we realise the role it plays in ground water recharge (as will be discussed elsewhere) and the importance of ground water in the present water supply situation of Bangalore. Even with a supply of 290 MLD of water,the percapita availability comes to only 85 litres while the desirable quantity is 200 lt.per head (Vyasulu & Reddy, 1985). This in itself has resulted in many areas having to rely on independent ground water supplies. Relying on ground water has become so unavoidable that the minimum distance of 250 mts. to be maintained between two borewells,has been forgotten. It has been reported that some borewell, open wells, nullahs and tanks have gone dry.

CHAPTER I C

Climate, Seasonality and Waterflow

The climate of Bangalore and its surroundings is essentially tropical but owing to its elevation (855-940 m),it is slightly on the cooler side. Based on the fluctuations in rainfall, temperature and relative humidity, four main seasons can be observed. The average annual precipitation in Bangalore is around 850 mm. The temperature and relative humidities can range between 15°C - 37°C and 25% - 95% respectively.

The hot-dry season extends from late February till the third week of May. The relative humidity generally falls below 35% during this season. However due to periodic thunder storms usually due to depressions in the Bay, the relative humidity can soar up rendering the weather extremely sultry.

The period from last week of May till the end of September can be termed as the hot-wet season. During this period,pre-monsoon rains are received usually from the last week of May to the end of first week of June. Then onwards the South-West monsoon is active. South-West monsoon showers have a moderating influence on temperature. Two peaks in rainfall during May and September can be observed in Bangalore.

The cool-wet season is during October and November. The temperatures continue to drop during this season. Rainfall received during this period is due to the retreating South-West, and North-East monsoons.

The cool-dry season extends from the end of November till February. The skies are cloudless and clear with most of the mornings being misty and cold. By the beginning of this season most of the tanks are full.

The seasonal changes also govern the flow and level of water in the tanks. The tanks get filled due to the monsoon inundation. Most of the tank water outflow is for irrigating the rice crop. In Bangalore, predominantly two rice growing seasons can be noticed. The monsoon cropping season is from June to December and the summer crop is taken up from January-February to May-June. The cultivation of summer crop solely depends on the availability of sufficient water in the tanks. Wherever the tanks are very shallow, only the monsoon crop is taken up. Most of the tanks in and around Bangalore invariably go dry by the end of April, unless there is a perennial source of water either in the form of sewage or industrial effluents(eg.Hebbal tank).

CHAPTER II A

Structure and Ecology of Irrigation Tanks and their utilisation by Birds

A village irrigation tank can be viewed as a basin with several zones of water of varying depths, surrounding a deeper zone that lies towards the bund (Fig.1). This zonation of water promotes the growth of a variety of emergent (e.g. Typha, Cyperus, Grasses); floating (e.g. Ludwigia, Salvinia, Azolla) anchored floating (e.g. Nymphaea, Nelumbo) and submerged (e.g. Hydrilla, Chara, Potomogeton) aquatic vegetation, each of which show a preference to a particular range of water depth. Also, because of the differences in growth habits and structure of these plants, vertically stratified vegetation layers result. These freshwater plant communities accommodate a large number of organisms especially insects, which form the staple diet of many species of invertebrates and vertebrates in the tanks' food chain. For example, chironomidae (nonbiting midges), often represented by a number of species are devoured at various stages of their development by predatory insects, fish fry, adult fish, spiders and birds. Food chains in these tanks can often be complex. The system is more or less a closed one, where everything is consumed and re-used, and where the balance between the various forms of life is very sensitive to change. Light, temperature, and the availability of oxygen and nutrients govern the growth of plants, of which smallest and simplest are phytoplankton, which in turn are devoured by zoo-plankton, insect larvae and fish fry and even some adult planktivorous fish and birds like ducks. Even the tank sediments support a large variety of soil invertebrates which thrive on organic matter from decaying plants and animals. These invertebrates are inturn eaten by a variety of other predatory animals like fish and birds (e.g. Flamingo and Spoonbill), sometimes along with the sediments itself. Thus the food chain lengthens and branches, involving many plant and animal species, and at the end of this foodweb, is man himself.

As may be seen from the above, the availability of abundant food, zonation of water and vegetation layering, create a habitat that is highly heterogeneous. Continuous release of water for irrigation and loss of water due to evaporation subjects the tank to constant change. Such an unstable situation in the tanks makes them very dynamic in nature. Heterogeneity and dynamic condition of the tanks create a habitat diversity that results in a high aquatic bird diversity. An example of how different groups of birds utilise an irrigation tank is illustrated in Fig.2.

Depending on their size and the availability of food and suitable conditions for foraging, different bird groups can be seen occupying different regions of the tank. Most abundant bird populations can be found in regions of the tank where the water is shallow (upto 40 cm deep) and vegetation is present.

Shallow water areas are occupied by a variety of wading birds based on their leg lengths. Accordingly, waders with longer legs and longer beaks (e.g. godwits, stilts, egrets, ibises,storks and herons) can be seen frequenting waters of depths up to 40 cms. Still shallower regions i.e. towards the shoreline is preferred by a variety of short legged birds like egrets, Pond Herons, ibises, Ruff, sandpipers and stints.In areas with shallow water, where sedges and such other vegetation abound, snipes and Wood Sandpipers can be expected.

Areas with emergent vegetation are frequented by several sulking species such as crakes, waterhens and other rails. Waters with floating vegetation (e.g. hyacinth and water lily) support Purple Moorhens and Jacanas.

Beyond the emergent vegetation, the open water zone provides an ideal condition for a variety of swimming birds like dabbling ducks that often sift floating plankton/vegetation and feed on submerged aquatic vegetation. Other birds mostly divers, that thrive mainly on fish and aquatic insects (e.g. pochards, pelicans, cormorants and grebes) are found in deeper clear waters where plants are less common.

The mudflats which usually border the shoreline are frequented by short billed plovers which usually pick up prey from soil surface. A few birds such as Common Sandpiper and lapwings can be expected on the short grass meadows close to the mudflats.

CHAPTER II B

Importance and Role of Aquatic Vegetation

As fish food: Aquatic plants play a very important role in the food web as primary producers. They are more useful than harmful to fisheries and play an important role in the phosphorus and nitrate cycles in freshwater ecosystems. They provide shelter and shade to fish and their fry, and some fish even require aquatic plants for attaching their adhesive eggs.

Aquatic Periphyton: In terms of providing fish food organisms, aquatic plants play an extremely important role. They are able to provide food for a variety of fish species of different sizes. Some fish (very few) directly feed on such vegetation. A more important role is that vegetation submerged in water provides extensive surface areas as substrates for periphyton organisms on which many fish species browse directly upon or for other organisms which in turn become prey for some other fish species. Hence another branch of the food web starting from periplyton

and culminating with fish or fish eating birds also takes its origin from aquatic vegetation.

Ecological cycle: As is true with any ecosystem, considerable amount of nutrient input is shunted back into the ecosystem (autochthonous input) by the decay and decomposition processes which convert the dead aquatic vegetation back into base nutrients in the tank water.

Reduction of turbidity: Colloidal soil particles which otherwise would not settle,are settled by neutralisation of their charges. This is brought about both directly and indirectly by aquatic plants. Release of positive ions during photosynthesis, and production of carbonic acid during respiration and other acids during decomposition, lead to neutralisation of charges. Oxygen production during photosynthesis is responsible for oxidising iron from ferrous to ferric state.This leads to the formation of stable ferric phosphate complexes which makes 'phosphorus' available in the dissolved state to the plankton.

Aquatic vegetation and plankton: Aquatic vegetation also helps keep tank waters clear by depriving the basic nutrients for plankton production and thereby controlling plankton growth which would otherwise render waters green. But in other situations, death and postmortal processes of the vegetation ploughs back basic nutrient inputs which can be taken up for the growth of plankton populations. Floating plants when overgrown could also cut off light for plankton. Therefore,it becomes clearly evident that presence of aquatic vegetation in adequate amounts is extremely important to keep an aquatic ecosystem (tank) naturally complete.

Waste water treatment: Compounds containing nitrogen and phosphorus are common pollutants in; they also happen to be major ingredients in fertilisers. Some aquatic weeds can extract these materials from water and incorporate them into their own structure. Researchers in a number of laboratories have recently found that these plants can be used to treat sewage effluent so that dissolved nutrients are recovered for re-use. Dangerous heavy metal ions are also known to be efficiently absorbed and assimilated in the tissues of these plants which can also be recovered through appropriate technology. However,prior to this metal ions can at least be separated from the waste waters and to that extent,dangers of metal ion pollution can be greatly reduced. Experiments are now underway to purify municipal sewage, industrial waste water and pigfarm and dairy waste water by growing aquatic plants in them. The appropriate use of such plants on being harvested should also not be very difficult.

CHAPTER III
METHODOLOGY

Extent of Coverage

The tanks that were located along all the major roads leading out from Bangalore were selected for the study. All those tanks that fall within about 30 km radius from Bangalore were considered. Thus, in all about 97 tanks were studied. Geographically the limits of the coverage ranged latitudinally from 12° 40'N to 13° 13' N and longitudinally from 77° 23'E to 77° 57'E. The easternmost tank covered was Tavarekere on Old Madras Road. The westernmost tank was Nelamangala tank on Tumkur Road; The northernmost being Dodda Tumkur and Aradeshahalli Tanks and the southernmost being Harohalli on Kanakapura Road.

Bird Census

At every site, two counting groups were involved. One group counted the birds in open water from the bund or embankment, while the other group counted the birds by going round the tank close to and along the shoreline. Whereever the tank was large the team split into three units for counting the birds; one on the bund, and the other two covering the tanks from opposite sides along the shores till they met. Further, counts from the immediate vicinity of the embankment to about 50 m on the downstream side was also integrated with the tank count.

Precaution was taken to prevent overlapping counts. This was achieved by not only zoning the tanks as described above, but also by maintaining records and exchanging information later, on moving and flying birds. Gross counts were first taken in the case of large aggregation of birds. Species-wise recounts were taken later.

Water Sampling

Water and plankton samples for analyses were taken close to the bund, as these were expected to give more comparable results as far as water and plankton samples were concerned.

Water samples were collected for the purpose of carrying out various analyses in the laboratory. About 1.5 lits. of water from each tank was stored in a properly labelled polyethylene container and preserved by adding adequate amount of Toulene. In the laboratory, some of the important factors concerning water quality were analysed using standard methods for water analysis.

Another sample of (0.5 lits.) was fixed in a separate, labelled polyethylene bottle, in the field itself and analysed in the laboratory for estimating dissolved oxygen, using modified Winkler's method at the end of the day's collections.

Vegetation

Aquatic vegetation of different kinds (ex.free floating, anchored (rooted) floating, anchored submerged, emergent, (grasses, emergent reeds and shrubs, etc.) observed growing in the shallow shore areas were collected and stored in polythene covers, labelled and carried to be identified later. Some of the easily identifiable plants were noted down in the field itself. The nature and predominance, etc. of the shore vegetation was also noted in the field.

General Information

General information about the tank as needed to cover our objectives about the waterfowl census and wetland survey,were collected through observations and dialogues with the local inhabitants, farmers and other people we met near the respective tanks.

Itinerary

Please refer to appendix for details of initials. The Forest Department vehicle was used on all days except those marked with an asterisk.

January 9th Monday: SS, OCN; Jalige, Ardeshahalli, Dodda Tumkur, Kodatur Singanayakanahalli - Dodda Ballapur Road.

January 10th Tuesday: SS, OCN, AM; Anneswara,Dodda sanne, Chikkasanne, Sadahalli, Kannamangala - Devanahalli Road.

January 11th Wednesday: SS, OCN; Gummanahalli, Doddajala, Chikkajala, Bagalur, Anchappanahalli, Kogilu, Channahalli - Bagalur Road, Devanahalli Road.

January 12th Thursday: SS, OCN;Bandekodigenahalli, Harohalli, Gantiganahalli, Budigereammanni, Allasandra-Bagalur road to Old Madras Road.

January 13th Friday: SS, NS, BKC, AM; Nelamangala, Binnamangala, Arasinakunte, Anchepalya, Huskur, Bommashettihalli-Tumkur Road.

January 14th Saturday: a. SS, OCN; Rampura, Kalkere, Doddagubbi, **Hennur** - Hennur Road. b. MBK,NS,BKC; Kodipalya (Nagaruru) Alur, **Maduhurekre - off** Tumkur Road.

January 15th Sunday: a. SS,-JNP; Yelahanka, Hebbal, Kodigehalli. b. MBK,NS; Nagavara, Rachenahalli, Jakkur.

January 16th Monday: MBK, OCN; Kaikondanahalli, Halnayakanahalli, Karmalaram, Gunjurpalya, Gunjur, Dommasandra, Yamri, Sarjapura, Vartur, (Agaram) - Sarjapur rd - Varthur rd.

January 17th Tuesday: MBK, UHK, OCN; J.P.Nagar, Puttenahalli, Tatguni, New Obichudanahalli, Taralu, Gopalapura, Tatguppe, Harohalli - Kanakapura road.

January 18th Wednesday: a. MBK,OCN,UHK; (Doddahulimavu Chikkahulimavu) Bodigrama, Sakalvara, Manatapa, Bidurekere - Bannerghatta - Anekal Road. * b. AM; Odke tank, Kanchigaranahalli, Kallandoddi - Harohalli - Bidadiroad.

January 19th Thursday: MBK, MD, OCN; Jigani, Hennagara, Dyavasandra, Haragadde - Anekal road.

January 20th Friday: MBK, NS, AM; **Chikkabegur**, Doddabegur, Gulimangala, Huskur, Rayasandra - Hosur road.

January 21st Saturday: MBK, UHK, NS; Attibele, Aarehalli, Bidaraguppe, Nallurhalli (Whitefield), **Doddanekkundi, Tubarahalli** - Hosur Road, Airport road.

January 22nd Sunday: SS, MBK, UHK, NS, BKC, JNP, TSS, Sridhar; Yellamallappa Shetty, Mugbala, Yelchehalli, Hoskote, Taverekere, Old Madras Road.

*** January 26th Thursday:** a. MBK, BKC, SK; Madivala. b. ASM, UHK; Kannalli, Hirekere, Kommaghatta, Kengeri- Mysore road.

*** January 29th Sunday:** MBK, UHK, SK; Lalbagh.January 31st Tuesday:

*** January 31st Tuesay :** UHK, SK; Chikkahulimavu, Doddahulimavu - Bannerghatta Road.

* **February 5th Sunday:** BKC, SK; Madivala, Agaram, Ulsoor tank, Sankey tank, Yediyur.

* **February 8th Wednesday:** UHK (V.Sudhir Kumar); Yediur tank.

* **February 9th Thursday**: SK, UHK; Sankey tank.

* **February 12th Sunday:** BKC; Madivala, Lalbagh.

CHAPTER IV A

WATER QUALITY CRITERIA OF TANKS SURVEYED IN AND AROUND BANGALORE

V.R. Ramakrishna Parama, K.Siddaraju, H.M.Chidanandappa, K.Sudhir, Badrinath and B.K.Chakrapani.

ABSTRACT

The irrigation quality of 78 tank water samples of Bangalore area were evaluated. The waters were of sodium, calcium, magnesium, potassium cationic type and carbonate, chlorine, bicarbonate anionic type. Over 85 percent of the waters could be used for irrigation satisfactorily in the prevalent coarse textured red sandyloams for all types of vegetation. There is a need to provide adequate drainage when C_3S_1 and C_4S_1 type of waters are used. Waters of C_4S_2 should not be used for irrigation. Most of these waters are potable but those within and on the outskirts of the city are seriously threatened. Owing to the proximity of industries,fertilised fields and other sources of pollution there is a need to protect these tanks from pollution.

INTRODUCTION

A Permanent prosperous agriculture is dependent on an adequate supply of irrigation water of satisfactory quality. Quality denotes suitability in relation to its effect on soils and crops and on the management that may be necessary to obtain optimum returns from the soil. The suitability is dependent on the salt present and therefore it is essential to have a knowledge of the kind of salts and their quality.

In Karnataka, tanks form a major source of irrigation water covering nearly 30 to 35 percent of the irrigated area. In Bangalore area there are as many as 130 tanks which provide substantial irrigation. Of late some of these tanks have been contaminated by effluents and other pollutants emanating from ever increasing industries, human habitations and this has posed a major problem not only in terms of maintenance of good irrigation quality but also to the existence of aquatic fauna and flora and to human beings.

Therefore an evaluation of the water quality of tanks in Bangalore area was undertaken with the objective of providing information about water quality and related soil and crop management.

MATERIALS AND METHODS

Water samples from tanks located in Bangalore area were collected during January,1989 and were analysed for pH, electrical conductivity (EC), water soluble cations viz, sodium, calcium and magnesium and Anions viz, chlorides,carbonates and bicarbonates following standard methods as outlined by Richards (1954).Trace elements such as boron, iron, manganese, copper and zinc were estimated using atomic absorption spectro-photometer. Residual sodium carbonate (RSC) and sodium absorption ratio (SAR) was computed using the equation put forth by Eaton(1950).Classification of the water with respect to their quality was done based on the methods as outlined in Handbook No.60 of USDA.

RESULTS AND DISCUSSION

1) Irrigation Quality

The chemical composition and other parameters of the tank water samples are presented in Table 1. The water samples had pH ranging from near neutral (7.3)to alkaline (10.0) with a mean of 8.3 indicating an alkalinity. The electrical conductivity(EC) of the waters ranged from 132 to 9600 μ mhos/cm with a mean of 948 μ mhos/cm which means that the content of Total Soluble Salts is on the higher side requiring caution in the usage of such (high salt) waters.

Of the cations sodium was the most dominant followed by calcium, magnesium and potassium. The contents ranged from 61.9 to 0, 4.4 to 0.5 9.2 to 0.1 and 4.3 to 0.03 me/lit respectively with mean values of 2.4, 1.54,10 and 0.38 me/lit respectively. The tank waters of Bangalore are Na, Ca, Mg, K cationic type.

The Sodium absorption ratio (SAR) of the waters ranged from 71.14 to 0.0 with an average of 2.19 . Except for two water samples, all the water samples had SAR less than 10.

Variation in RSC was also observed wherein the maximum was +61.01 and the minimum was -0.03 with an average of +2.19 me/lit.

Of the anions, carbonates were the the most dominant with a maximum of 57.0 and a minimum of 1.52 me/lit averaging 10.95 me/lit. The second dominant anion were chlorides followed by bicarbonates with mean values of 3.93 and 1.95 me/lit respectively. The tank waters were CO_3>Cl>HCO_3 anionic type.

The quality of these waters were rated based on the standards set by USDA (Richard,1954) which takes into account a)Total concentration of soluble salts (EC)

b) Concentration of Sodium ions in proportion to Calcium plus Magnesium - sodicity. c) Concentration of Carbonates plus Bicarbonate ions in excess of Calcium plus Magnesium (RSC) and d) Trace elements such as Boron etc., that may be toxic to plant growth if present in limits beyond the permissible (Table 2 & 3).

Based on this classification there exists a variation in waters with respect to the content of dissolved salts (EC) over 50 percent of the water belonging to the C_2 class followed by 18,19 and 10 percent in C_1,C_3 and C_4 classes.

Waters of C_1 and C_2 classes could be used for irrigation without major hazards to soil and crops. Waters of C_3 and C_4 class which make nearly 30 percent of the waters are not suitable for irrigation since they lead to salinity. However instances exist of their use in agriculture, occasionally under very special circumstances. Since plants take most of its water from the upper part of the root zone and respond more critically to salinity level in its lower depths using normal irrigation practices (Bernstein and Francois, 1973) management of this critical upper root zone is as important as providing adequate leaching to prevent salt accumulation in the total root zone. Thus soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops could be selected.

Almost all the tank waters have low sodicity posing least sodium hazard, only two samples being exceptions. These belonged to S_2 and S_4 class respectively. Inadequacy of leaching and drainage when using C_3S_1, C_4S_1,C_4S_2 and C_4S_4 would lead to salinity (Thorne and Peterson 1954 and Kanwar 1961).

A major factor affecting the final SAR value of soil water is the change in Ca+Mg concentration due to the precipitation or dissolution of alkaline earth carbonates. Although carbonate precipitation is common for many surface waters, its extent is often greater in ground waters. However as much as 92 percent of the samples have low RSC_2, these being safe for irrigation. Only three belonged to RSC, (marginal quality) hence to be used with caution whereas the three samples belonging to RSC_3 are unsuitable for irrigation (Eaton 1950).

The texture of the soil is one of the most important characters which governs the use of irrigation waters of varying degrees of salinity. The fact that saline waters containing salts upto 8g/lit (EC μ mhos/cm) could be used successfully for an indefinitely long period under favourable conditions of the soil has been recognised.

In Bangalore area the soils are usually red sandy loam and/or red loams; these being light textured with good drainage do not favour salt accumulation. However caution is advised in the case of C_3S_1,C_4S_1,C_4S_2 and C_4S_4 classes of water which contain salts and sodium leading to salinity and/or sodicity.

The contents of different trace elements and their critical limits is given in table 5. All the irrigation waters have less than 3 ppm boron (Normal water) and can be used for most of the tolerant and semi-tolerant crops in all soils without any injurious effect on the plants. With respect to other trace elements the contents are well within critical limits in majority of the waters.

In conclusion it could be pointed out that the waters of C_1S_1 and C_2S_1 could be used for irrigation satisfactorily. Caution is advised in the use of C_3S_1 and more so for waters of C_4 class which have high sodicity, there exists a need for good soil management when using these waters.

Special mention needs to be made in respect of Hennur Tank and Arehalli tank waters. The analysis of these waters indicate that they are totally unfit for irrigation. Further,these two waters are continuously subjected to environmental pollution from nearby industries.

2) Evaluation of Tank Waters for their Drinking Quality

The chemical concentrations and parameters in relation to drinking quality of tank waters is presented in Table 5. These data have been considered on the basis of Indian & ICMR standards (Manivasakam, 1974). On comparison of these two standards, the Indian standards permit lesser content of the chemical constituents than the ICMR standards. On general considerations from data available at present, over 75% of the tank waters could be used for drinking. The chemical contents for these tank waters are generally well within the safe limits. However, nearly 45% of the tanks had water having iron more than 1 mg/l (ICMR classification).

From Table 5, it is evident considering pH, dissolved solids, chlorides and iron, that 6.4, 11.5, 12.8 and 46.0% respectively, of the tanks including all City tanks have higher levels than the limits prescribed by the ICMR. Pollution of various origins could be the main reason for this finding. Further if Indian standards are considered for comparison, a much larger number of tanks spanning a few more water quality parameters are brought into the higher than critical limits fold. Notable increases are seen for iron, pH and dissolved solids which now show 87.0, 26.0 and 26.0% of the tank waters being above critical limits respectively.

It is interesting to note that a number of tanks on the fringes of the city are getting into the fold under these critical considerations. This definitely indicates a dangerous trend as pollution from industrialisation, sewage, etc., are expected to increase with the growth of the city.

Nothing can however be said about the water quality in these tanks concerning their bacteriological status. Microbial/bacterial quality and quality of tank waters provide critical information at least in as far as drinking water quality is concerned.

Though nothing can again be said in concrete terms about factors like suspended/colloidal particles, surfactants, sulphates, phosphates and nitrogen sources, as their levels have not been assessed, it is feared that their influence may slowly turn most tank waters unsuitable for any form of life. This may be already true of tanks within and close to the city since an increased use of detergents, a shift from using ordinary soaps, release considerable amounts of sulphur based surfactants possibly in dangerous quantities. Nitrates and Phosphates could any way be brought in through other domestic and industrial waste effluents. These may spread to more tanks as more development is envisaged. Thus, the waters in many tanks could be much more unsafe than the data gathered in this study suggest. Some of the observations on plankton do seem to suggest the existence of some of the above types of pollution.

None of the tanks are found wanting in required level of dissolved oxygen (DO). Most of the tanks which showed more than 14 mg/lit of DO however, supported blue green algal blooms even during a cold month like January. Such high DO concentrations can therefore be dubious, being present only in surface waters due to releases from photosynthetic activity. Waters at lower levels would thus be depleted of DO which could then support only a very limited variety of aquatic organisms. Such waters are proven to be of highly doubtful quality in terms of potability. Surfactants have the property of bringing down the DO levels drastically at least in pockets where washing is common or frequent. Rest of the tanks, are seen to indicate fairly good or adequate levels of dissolved oxygen. The critical minimum of 3mg/lit DO of either Indian or ICMR standards however refers to piped water supply. In lakes or water bodies such low DO levels can hardly support diverse populations of aquatic fauna or flora. For this, the recommended levels are a minimum of 5 mg/lit and above 8 mg/lit for healthy and productive tank waters.

In terms of biological quality, many of the tanks show the presence of Nematodes which indicates considerable human influences like faecal contamination. This is unhygienic.

3) Evaluation of Tank Waters for their Productivity Potential

The daytime water temperature as observed during the census period was quite conducive for primary production (PP) by plankton organisms. Though the survey period (January) falls well within the winter season, the atmosphere is cool only during the late night and early morning hours. During daytime, the skies are mainly clear and sunny, ensuring good light and temperature conditions for plankton . The

rate of PP however would be moderate as compared to high rates possible during summer months.

From the results based on the 97 tanks surveyed, it is observed that 16% of the tanks are dry and heavily silted and 35% of them possess enough silt for mudflats to have been formed; 47% being associated with brickmaking. This activity also contributes to a large extent, towards the muddy colour of water. Though January is not a rainy month for increased silt deposition, of the tanks with water, 78% possessed muddy/murky water.

Tank water colour provides useful clues to make a quick preliminary assessment of some key environmental parameters influencing the aquatic eco-system. Sewage eutrophication rendering the waters green has been noted in 10%. At least 15% of the tanks already have or would seem to have effluents other than sewage. Also observable from the survey was that a mere 12% of the tanks possess clear water. The dissolved solids themselves are found to be above critical limits in 26% of the tanks. All the activities mentioned elsewhere, along with the presence of a highly disturbed shore area devoid of vegetation, combine to make the waters turbid to a large extent. Erosion is therefore considerable from the shores and catchment areas of most of the tanks.

Turbidity present in 88% of the tanks, is a highly significant parameter as far as the levels of PP in a waterbody is concerned and the two are inversely proportional. Turbidity is caused mainly by presence of solids of various origins which remain suspended in the tank waters. Silt particles, organic matter, sewage and other effluents can all contribute to this factor. Organic matter derived from aquatic vegetation/shore vegetation litter etc., is mainly colourless but silt or mud provides a brown or muddy colour and sewage, industrial and other effluents can bring about a murky colour change. All these, bring about a reduction in the transparency of tank waters and retard light penetration to a large extent. Thereby the productivity of the tanks as a whole would be severely affected. Turbidity introduced into tank waters would not clear-up quickly because of convection, mixing and wind action. Therefore the productivity of most of these tanks cannot be satisfactory or optimal.

Tanks which are fed by sewage, turn eutrophic as observed during the survey. Over a period of time, blue-green algal blooms become a permanent feature turning the waters green. Such waters cannot support a diversity or number of organmisms. Other pollutants also render the waters unproductive as a number of organisms cannot survive in such conditions.

An electrical conductivity of about 400 μ mhos or more is considered ideal for healthy production of plankton, vegetation, fish and other organisms. 34.6% of the tanks recorded conductivities of more than 400 μ mhos. However, 20% of these

tanks, recorded conductivities ranging from 750-2250 μ mhos, which is high and 10% tanks had very high values (>2250 μ mhos). All the tanks recording more than 750 μ mhos were however, located within, close to or on the fringes of the city.

Only one tank (Dyavasandra), recorded 7.2 mg/lit of dissolved oxygen. All others ranged from 8 to a maximum of 25 mg/lit. Blue green algal blooms were found in 18% of the tanks. Most of these were either city tanks or ones fringing the city.

It is to be noted that the timing of the survey was in January, a period stable in terms of both the volume of water held and moderate winter weather conditions. It is feared that in the tropics, many of the parameters like dissolved salts, ions, nutrients and trace elements etc., would increase considerably in their concentration during summer months. At this time water volumes are low, and evaporation rates and the incident light energy are high.

Thus the overall influence of the above parameters concerning water quality criteria indicate that all is not well as far as the present ecological status of many of the tanks surveyed is concerned. The main threats to water quality seem to emanate from erosion (various reasons), pollution and bad or lack of scientific shore management practices. The extent of inflow of excess of nutrients through fertiliser applications, pesticide and insecticide residues in tanks also need to be assessed.

All the above phenomena operating in combination therefore, would certainly pose problems in the future and have a serious bearing on the quality of these tank habitats and the aquatic flora and fauna supported by them. The immediate and most severe observable stress would be on the waterfowl dependent on these floral and faunal resources. Serious attempts to redeem such situations are therefore urgently needed.

CHAPTER IV B

AQUATIC MACROPHYTES

Presence or absence of major forms of vegetation(i.e., submerged, emergent, free floating and anchored floating) was recorded for the tanks.

Chara, Nitella, Hydrilla and Vallisnaria were common submerged forms. In some tanks Hydrilla and Chara formed extensive patches/tracts and covered almost the complete tank bed. Species of the genera Utricularia and Trapa were seen in small patches in a few tanks only.

Some of the free floating forms belonged to the genera Ludwigia(L. adscandens, L. prostrata and L. perennis) Marsilia, Salvinia, Wolffia, Lemna, Azolla and Eicchornia.

Emergent plants were quite common. The genera recorded are: Typha, Scirpus, Cyperus (2 sp.) Rotala, Polygonum, Amania, Ipomoea, Lippia and Hygrophylla. Many of these plants form dense patches which give cover and shelter for the birds especially when they are breeding.

Anchored floating plants recorded were Nymphaea, Aponogeton, Potomogeton and Nelumbo.

Many other species were come across on the wet grasslands on the shores. They are: Eleaocharis sp., Sphaeranthusindicus, Commelina benghalensis, Cyanotis sp., Exacum bicolor, Canscoria diffusa, Alternanthera sessilis and many grasses.

CHAPTER IV C

ANNOTATED BIRDLIST

Note : Residential status refers to the area of the survey only. Only tanks with water have been taken into consideration for the calculation of percentages.

Podiceps ruficollis : Little Grebe

Resident subject to local movements. This is principally a fish eating species affecting deep water regions of the tank, but its floating nests are built among aquatic weeds. This is one of the widely distributed species found in 27 % of the tanks. Though it occurs in small numbers an unprecedented count of 552 birds was recorded at Vartur.

Phalacrocorax niger : Little Cormorant

Uncommon non-breeding resident. This is mainly a piscivorous bird diving to catch fish. Hence requires water with low turbidity. Since this group does not oil its feathers, the feathers get wet while in water. This necessities that the birds dry their feathers periodically which they do on exposed perches like boulders, bushes and trees. As such this species is found in a restricted number of tanks with the highest count of 11 birds at Singanayakanahalli.

Phalacrocorax fuscicollis: Indian Shag

Habits same as above. This species requires further studies. Only one individual sighted at Hennagara.

Ardea cinerea: Grey Heron

Non-breeding resident, not uncommon. This is a large solitary species wading into deep waters in search of fishes frogs and other large aquatic invertebrates. The highest count for the species was 8 at Jigini and was sighted in 22% of the tanks.

Ardea purpurea : Purple Heron

A rare non-breeding resident. It is a species requiring a good growth of emergent vegetation in which is hides itself. Often it can be seen on large patches of water hyacinth even in the middle of tanks. At times it can also be seen standing in open water in larger tanks but only when the water is very shallow.

Ardeola grayii: Pond Heron

An abundant resident. One of our smallest herons; found in 80 % of the tanks, the highest count of 70 birds being at Doddanekkundi. A successful species found from the smallest pools to the largest tanks and reservoirs. This is one of the few species

which has been benefited by man's transformation of the natural habita t into cultivated wetlands.

Ardea alba (Egretta alba) : Larget Egret

A less common resident recorded in 26 % of the tanks, the highest count being 11 birds at Yelahanka. This is one of the largest species of the family (group) occuring in our area. Usually found solitarily or in small numbers in larger tanks, often wading into water, 40-45 cm deep. A good number of this species can be seen in early summer when larger tanks have vast stretches of shallow water. Feeds on fishes, and other aquatic invertebrates.

Egretta intermedia : Median or Smaller Egret

A common but not an abundant resident. Recorded in 30 % of the tanks with water; highest count of 15 birds at Hennagaa tank.

Egretta garzetta: Little Egret

An abundant resident, found in 78 % of the tanks, along with Pond Heron, the most extensively found species in our wetland habitats. Single largest count was 49 birds seen at Anneswara. A shoreline species sometimes aggregating into large numbers, feeding on a variety of small animals in the shallows, on larger insects, small fishes, frogs, tadpoles etc.

Bubulcus ibis: Cattle Egret

An abundant resident. A gregarious species but found in only 43 % of the tanks. Largest number at a single site was at Hebbal, where a record number of 548 birds were counted. The birds were seen feeding on the expanse of water hyacinth along the edges of the tanks. This is the most unconventional of our herons and egrets, often found 'attending on' cattle far away from water, feeding on the flies and grasshoppers distrubed by the grazing cattle. Once restricted to Africa and South East Asia this species has in the recent decades extended its distributional range globally.

Egretta gularis: Reef Heron

A rare vagrant, only one individual in grey phase recorded at Hennagara tank. Common towards the coast, uncommon inland. Known to hunt actively, rather than adopting the wait and strike method of other herons and egrets. More information on the species in our area desirable.

Anastomus oscitans: Openbill Stork

An uncommon non-breeding resident,(common in Mandya & Mysore districts). Found in only 4 % of the tanks during the census. The highest being two birds sighted at Kannali. One of our smallest storks, specialised for feeding on gastropods. 80 % by weight of its food is accounted for by just two classes:, Gastropoda and Crustacea (Mukherjee, 1974).

Ciconia episcopus: Whitenecked Stork

Uncommon rare breeding resident. Found in 5 % of the tanks, 7 birds being recorded at Kodathur. Feeds usually on frogs, crabs, molluscs, reptiles and large insects (Ali & Ripley '78).

Pseudibis papillosa : Black Ibis

Uncommon non-breeding resident.Five individuals recorded at Doddabegur tank. Ibises are basically marshland birds probing the ooze for worms, insects, crustaceans, some vegetable matter, small fishes and frogs, etc. Among the three species, Black Ibis prefers to feed on more drier ground than the other two.

Threskiornis aethiopica: White Ibis

Uncommon non breeding resident. Four individuals recorded at Hennagara.

Plegadis falcinellus: Glossy Ibis

Uncommon migrant and partial non-breeding resident. Recorded last year at Jakkur tank.

Nycticorax nycticorax: Night Heron

Though not even a single bird of this species has been recorded in any of the tanks censused, the species is fairly common within Bangalore City limits.Night Herons have been nesting within the city in the residential localities of Malleswaram and Basavanagudi, where it nests on tall dense canopied trees like Jack, Copperpod Tree (Peltophorum)and Manilkara.The species is crepescular and noctural (during the non-breeding season). The birds are very noisy during the breeding season. Roosts also in thick canopied tall trees like Banyan, Tamrind, etc. (eg. at Hebbal).

Mycteria leucocephala: Painted Stork

Uncommon non-breeding resident. This species breeds in Mandya district at Kokkare Bellur. Though this species was not recorded during the present census, individuals in small flocks have been sighted flying overhead at other times.

Ciconia ciconia: White Stork

Rare winter visitor. White Storks were first recorded in Bangalore in 1983 and later at Jakkur (1987) and Begur (1988). No record of this species exists for this year's census. The count of 11 birds recorded in 1983 at Hebbal has been the highest recorded. This species requires shallow water tanks and does not tolerate disturbance.

Dendrocygna javanica: **Whistling Teal or Tree Duck**

An uncommon resident, subject to local movements. Recorded in only three tanks with a highest count of 58 birds at Jigini tank. The species restricts itself to shallow weedy margins of large tanks and often can be seen dabbling in an inch deep water. Usually seen in small numbers but congregations of over several hundred also seen.

Anas acuta: Pintail

A very common migrant duck,recorded in 27% of the tanks. The highest number of birds (674) were seen at Budigereammanni. Usually seen in medium and large tanks with other Anas and Aythya species. Usually found in the deeper regions of the tank but comes to the water edge to preen when there is no disturbance. Spends the day roosting on the water and flies out at dusk to feed in paddy fields, etc. (Ali and Ripley,1968).However a few individuals can be seen feeding in the tank waters even during the day.

Anas crecca : Common Teal

A less common winter visitor. Of the six tanks, where the species was recorded, 401 was the highest count obtained at Singanayakanahalli tank. Seen in company of Pintail and Garganey.Unlike the latter, prefers shallower and more weedy tanks for foraging (eg: Singanayakanahalli and Begur tanks,1987).

Anas poecilorhyncha: Spotbilled Duck

A common resident. Of the seven tanks in which the species was recorded, Jakkur tank had the highest tally of 28 birds. Usually occurs in very low numbers and frequents reedy and vegetation-covered tanks. The species is highly nomadic and locally migratory.

Anas penelope: Wigeon

An uncommon winter visitor. In addition to Madhurekere wehre 29 birds were recorded, two more tanks had this species in low numbers. Less abundant and less common (?) than last year. Found in the company of Garganey & Common Pochards in deeper waters. Usually roosts during the day in open waters and flies out of the tanks to feed during the night in paddy fields (Ali and Ripley ,1968).

Anas querquedula: Garganey

The most abundant and commonest migrant duck. Recorded at 23 % of the tanks with a highest count of 2087 at Budigere Ammani. Large populations can be seen in large tanks invariably seen in the company of Pintails. Also uses many small tanks as roosting sites, flying out at dusk for foraging.

Anas clypeata: Shoveler

A less common migrant.Recorded in 8.5% of tanks, 289 birds at Hennagara was the highest recorded. Its beak is broad and flattened into a shovel shape with which

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A less common migrant.Recorded in 8.5% of tanks, 289 birds at Hennagara was the highest recorded. Its beak is broad and flattened into a shovel shape with which

it sifts minute floating organisms from water surface. Usually it is seen along with other dabbling ducks (Anas spp).

Aythya ferina: Common Pochard

A less common winter visitor. This is the only species of diving duck frequently seen in and around Bangalore. It was recorded in 12% of the tanks with a highest tally of 325 at Hennagara. Frequents medium to large sized tanks with deeper water. Feeds mainly underwater. Therefore seen on open expanses in the middle of tanks.

Nettapus coramandelianus: Cotton Teal

A less common locally migratory resident. This species is the smallest of the ducks. Affects vegetation covered tanks and is usually seen in shallow water regions and feeds on vegetation on or close to the water surface. Recorded in 11% of tanks with a highest number of 158 birds at Anneswara.

Amaurornis phoenicurus: Whitebreasted Waterhen

Resident; not uncommon. During the census period, only one bird recorded at Allasandra tank. A highly shy bird and it can be seen invariably in tanks with dense vegetation along the water's edge. Owing to its sulking nature it is a bit difficult to see. Where there is no disturbance and human activity is less, the bird can be seen feeding away from its cover.

Amaurornis fuscus: Ruddy Crake

Uncommon resident. Only one bird recorded at Madivala. The bird is highly sensitive and shy. Always resides within the seclusion of tall emergent reeds growing in shallow water. With the slightest hint of danger or disturbance, it dashes into the cover of reeds. Because of its habits, the species is extremely difficult to see.

Hydrophasianus chirurgus: Pheasant-tailed Jacana

Once a common resident, now uncommon recorded only in 4% of the tanks with a highest count of two birds at Jigani tank. This species is specially adapted to walk on flat lilly like floating vegetation (eg:Nelumbo,Nymphaea sp.) which is essential for its survival. Control or removal of floating vegetation (water lilies, lotus and hyacinth) has seriously affected its numbers in the Bangalore area. Once upon a time it was abundant in many tanks including the now filled J.P. Nagar tank. Often it can be seen breeding in tanks with a sparse growth of water hyacinth.Other than the Puttenahalli tank the only site where the breeding of this species has been recorded so far has been J.P.nagar tank (1987) which is now filled up and destroyed.

Gallinula chloropus: Indian Moorhen

Not uncommon resident and partial migrant.Found in 2% of the tanks; the highest count of five birds being recorded at Lalbagh. Omnivorous but 90% accounted for by vegetable matter - submerged and floating aquatic weeds (Mukherjee, 1974).

Porphyrio porphyrio: Purple Moorhen

Once a common resident, has been recorded in 7% of the tanks. The highest count has been at Nagavara where 32 birds were counted. This species feeds on aquatic plants and was flourishing in tanks with good water hyacanth growth (e.g. Lalbagh, Hebbal, Nagavara) The decline in the growth of water hyacinth has resulted in this species becoming less common. This year's highest count is also associated with good growth of water hyacinth at Nagavara and Hebbal.

Fulica atra: Coot

Common resident and partial migrant recorded in 20% of the tanks; the highest count of 300 birds being at Jigani. The Coot feeds on both plant and animal matter though the former predominates (64% and 36% respectively - Mukherjee,1974). The population of this species is on the decline since the end of 1970s. (over 2000 birds at Hebbal tank in 1979).

Himantopus himantopus : Blackwinged Stilt

A very common gregarious migrant found in % tanks and the highest tally of 557 birds were recorded at Hennur. Due to its extra- long legs it can be seen wading into much deeper water than any other wader. Usually probes mud with its tapering beak for worms. The year to year population of this species appears to be on the increase.

Recurvirostra avosetta: Avocet

A very rare migrant (vagrant?) though an individual of this species was recorded in Jan 1989 close to Bangalore, near Tailur, Mandya district.This species has not been recorded in the tanks censused.

Vanellus indicus: Red-wattled Lapwing

A common resident; this species was encountered in 51 % of the tanks. Occurs singly or in pairs, very rarely in small flocks,along the water edges. The highest count was 14 birds each at Anneswara and Rampura. Frequents a variety of habitats.

Vanellus malabaricus: Yellow-wattled Lapwing

Resident. Recorded only in two tanks with the highest count of 23 birds at Nallurhalli. Prefers a more drier area and is found often in larger numbers than Redwattled Lapwing

Charadrius dubius: Little-ringed Plover

A common winter visitor.Recorded in 48 % of tanks with the highest flock size recorded at Kalkere.Though the species forages along the water margins in tanks, the population fluctuation is dependent on the availability of very wet mud flats.

Occurs in large numbers towards the end of its migratory period, when the tanks start going dry and offer vast mud flats interspersed with shallow pools of water.

Charadrius alexandrinus: Kentish Plover

An uncommon resident subject to local movements. Seen only at five tanks with the highest number of 190 at Kalkere. Found in the company of C. dubius and requires similar habitat conditions. As per past records, occurs usually in low numbers.

Limosa limosa: Blacktailed Godwit

Uncommon winter visitor. Recorded only in four tanks. The highest number of 123 was recorded at Dodda Gubbi. For a wader labelled as rare in Southern India, the population has been on the increase and is being seen more frequently than before. Probes wet mud in deeper waters.

Tringa totanus: Common Redshank

A rare winter visitor. One bird was seen at DoddaGubbi. Probes wet mud in standing water in company of other sandpipers. Common about 10 years back, it is becoming increasingly rare.

Tringa stagnatilis: Marsh Sandpiper

A common winter visitor. Encountered in 50 % of the tanks, maximum of 272 birds at Kalkere. A shallow water forager seen feeding with smaller sandpipers(e.g. Wood Sandpiper). It probes wet mud with its pointed beak. This species once rarely met with is becoming increasingly common.

Tringa nebularia: Greenshank

A common winter visitor. A solitary forager rarely seen in flocks. Occurs in low numbers. Usually seen foraging along the water edge and also in shallow water. Was recorded in tanks with the highest count of 39 birds at Bagalur.The species has become more common than what it was about five years ago.

Tringa glareola: Wood Sandpiper

A common winter visitor. Recorded at 66 % of the tanks with a maximum of 75 birds recorded at Arehalli. The species is more gregarious than any of the other sandpipers. Probes mud in shallow water close to the water's edge.

Tringa ochropus: Green Sandpiper

A common winter visitor. Recorded in 65 % of the tanks with the highest count of 26 birds at Anneshwara. Forages solitarily, probing wet mud in shallow water close to water's edge. Occurs in lower numbers than Wood Sandpiper.

Tringa hypoleucos: Common Sandpiper

A common winter visitor. This species was encountered in 68% of the tanks with the highest number of 34 at Arehalli. This is a species that usually forages singly, running about along the water's edge, picking titbits cast up by wavelets It can also be seen foraging on wet meadows a little away from the water's edge. It does not probe the soil like other species of the genus Tringa.

Gallinago spp : Snipes

Less common migrants. A total of 367 snipes were sighted in 40 % of the tanks. Of these in 8 tanks Pintail Snipes (G.stenura) were recorded with a highest count of 29 at DoddaTumkur. Fantail Snipes (G.gallinago) were recorded in 6 tanks with a maximum of 5 birds at Budigere Ammani. However, at 18 tanks no differentiation between the two species could be made. At Hoskote an overall maximum of 45 snipes was recorded. The two species of snipes could possibly be more abundant and widely distributed than what was recorded. Their obliterative coloration and secretive habits often make it difficult to detect them. Snipes forage singly or in flocks on marshy patches or beneath bushes along the shore, probing deep into squelchy ground with their long slender beaks.

Calidris minuta : Little Stint

A less common migrant. Though less widely distributed, often occurs in very large numbers in either scattered or dense active flocks on wet mudflats or along water's edge. Populations as large as 922 and 671 were recorded at Yelchehalli and Kalkere respectively. Found in 21% of the tanks.

Calidris temminckii: Temminck's Stint

A rare winter visitor. Three individuals only recorded at Nallurhalli. Forages along with Little Stint and often difficult to distinguish from it unless attention is paid to details.

Calidris ferruginea: Curlew Sandpiper

A very rare coastal migrant. Eight birds were seen foraging with Little Stints in a mixed flock at Manchappanahalli. Probes soft mud with their beak in shallow water. This is the only sighting since 1983 in Bangalore.

Philomachus pugnax: Ruff

A common, but less widely distributed migrant. Recorded only in five tanks with the highest number of 104 birds seen at Kalker. Forages in loose flocks probing wet mud in shallow water. This species is being seen more commonly than before.

CHAPTER IV D

UTILISATION OF ACACIA NILOTICA BY BIRDS

Under the social forestry programmes, the Forest Department has been planting the foreshore areas of tanks with Aacia nilotica to meet the fuel wood requirements of villagers. This species is slow growing and produces a fairly open canopy with a high density of long thorns. Also A. nilotica can tolerate water inundation. When grown as a dense stand, it forms an impenetrable barrier through which no man or large animal can pass, till the lower branches fall off.

During the present survey the census party at different tanks came across several instances of birds using the stands of A. nilotica for various purposes. Details are given below.

1. Refuge

Several species of birds namely Dabchicks, Pintails, Garganeys, Spotbilled Ducks, Common Pochards and Common Teals(at Jakkur and Singanayakanahalli tanks); White-breasted Water-hens and Coots (at Jakkur); Little Stints, Green Sandpipers, Wood Sandpipers, Marsh Sandpipers and Greenshanks (at Bagalur) were seen resting inside stands of A. nilotica in very shallow waters. The birds observed were either sleeping, preening or resting inside these stands. As observed at Jakkur, the entire duck population was inside the stand. Safety and lack of disturbance may have been the reason for the above bird species using the A. nilotica in the shallow foreshore area.

2. Nesting

In almost every tank which had isolated trees or dense stands of A. nilotica, nests of White-throated Munia (Lonchura malabarica) could be seen. The nests were placed inside the thorny canopy of A. nilotica over a height of 1.5 mts. At Jakkur, inside the dense crown of Acacia the munias were observed nesting in loose colonies. Several plants were seen having up to five nests. The dense thorny canopy seems to afford enough safety and good nesting sites for the munias.

Again at Jakkur, two nests of Coots were observed at water level on isolated A. nilotica standing in 1.5 mt. deep water. This was the first such sighting of Coots nesting in Bangalore. Coots usually build either floating or anchored nests made of aquatic plants in tanks. Nesting on plants in deep water is unknown for this species.

3. Resting

Little Cormorants were observed at Singanayakanhalli using A. nilotica standing in deeper water for drying their wet wings after fishing. The count of Little Cormorants was higher at Singanayakanhalli probably because of these inundated trees. Planting few plants of A. nilotica in deeper regions of tanks may entice species with similar perch site requirements for foraging.

4. Feeding

Two wading birds namely Pond Heron and Grey Heron which feed only along the shoreline in shallow waters were seen on isolated A. nilotica plants in more deeper water. These birds make use of the wait and strike technique to catch prey and the birds were perched on branches close to the water surface.

A few small Blue Kingfishers (Alcedo atthis) also were seen using A. nilotica in deeper water while feeding.

Bamboo

Role of thorny Bamboo in water is similar to A. nilotica so far as shelter and feeding are concerned.

CHAPTER IVE

NOTES ON SOME SELECTED TANKS

1. Hebbal Tank

Hebbal tank is one of the tanks seriously affected by disturbances, the inflow of sewage and industrial effluents. Prior to 1984 the tank had a distinct seasonal cycle. The tank used to go dry during the height of summer (April-May) and the fish and other aquatic fauna in the tank would collect in small shallow pools on the drying tank bed. To feast on this concentrated prey a variety of birds used to gather around the shallow pools and the wet mud flats would also attract a variety of birds. A count during April 1983 recorded 213 Pond Herons, 28 Grey Herons, 6 Whitenecked Storks, 11 White Storks, 466 Brownheaded Gulls, 1750 egrets, 4 Reef Herons, 26 Blackbellied Terns, 14 River Terns, 1315 Blackwinged Stilts, over 2000 Little Stints, etc. Today due to constant inflow of sewage and effluents the tank has water throughout the year. The bird populations have been reduced drastically, mainly due to reduction in habitat and aquatic vegetation diversity, unchecked growth and spread of hyacinth and increased human disturbance. The population of Coots that often reached over 2000 birds during 1979 can no longer be seen. A comparison of the present census count and at much smaller tanks elsewhere would give a grim picture of the situation.

Stopping the inflow of sewage and effluents, removal and checking the growth of hyacinth, and a slight deepening of the tank bed may restore the situation that once prevailed at the tank.

2. Singanayakanahalli Tank

This is a very shallow large tank which supports a good population of birds. The 1988 census and the present one indicate that the shallow waters of the tank are specially suited for a variety of waders and ducks. If developed, the tank can be an important waterfowl refuge. The main threat is encroachment by surrounding farms; as a consequence virtually no vacant land surrounds the shoreline. Shooting is another problem at the tank. But for these two factors this tank is a very healthy one in respect to bird abundance. When the tank has more water,the duck population increases and even pochards which frequent deep water tanks can also be seen. In the foreshore area a healthy stand of A.nilotica exists.

3. Hennur Tank

This is one of the tanks which has become a victim of city developmental activity. Before 1985 the tank supported over 17 species of birds like Spotbilled Duck, Common Teal, Garganey, Brownheaded Gull, Dabchick and Coot in addition to

small numbers of a variety of waders, namely stints, sandpipers, stilts and snipes. But as the years progressed the tank bed and its downstream areas were used for creating a residential area. This brought about drastic changes.

First, the tank bund was breached to drain the standing water and later the tank bund was removed completely. Secondly, road construction was taken up cutting across what was once the tank bund. Between 1988 and 1989 the progress of this conversion has been slow. In spite of the removal of the tank bund, the sewage inflow from the adjacent Nagavara village (town) coupled with some scant rain water accumulation, leaves a shallow stretch of murky water that can be seen towards late winter. This shallow stretch of water has been supporting as many as 11 species of waders that total upto several thousand birds. The only aquatic plant that grows in the murky water has been the water hayacinth.

Once the developmental activities are complete Hennur Tank site would be a standing example of the effect of urbanization on bird populations.

4. Anneswara Tank

This is one of the large tanks which has both deep and a vast extent of shallow water. Also the tank supports a good number of aquatic plants. The birds in the tank are threatened by poaching and in addition, the tank bed is being encroached by surrounding agricultural and horticultural farms, and extensive mud lifting goes on throughout the year. With proper care and removal of the above threats, the tank has the prospect of becoming a good bird refuge. Extensive foreshore planting can be taken up.

6. Budigere Ammanni Tank

This tank is one of the largest tanks in North Bangalore. The highest number of Barheaded Geese (48) and Brownheaded Gulls(19) were counted here. The tank has poor aquatic vegetation, and encroachments by surrounding farms extend till the shoreline all around the tank. Mud lifting and brick making are prevalent. The high duck and goose count may probably be due to the vastness of the tank. With the removal of the threats from poaching and encroachment of the tank bed, the tank will serve as one of the important wintering site for both resident and migratory waterfowl within Bangalore limits.

7. Chikka Sanne Tank

This tank is again one of the larger tanks is North Bangalore. In spite of its large size poor counts of ducks have been recorded.This is probably due to its turbid (muddy) water and lack of any aquatic vegetation. Turbid water indicates high silt

movement into the tank from the surrounding farms that have encroached into the tank bed.

8. Kalkere Tank

This tank is one of the least affected so far by mans' activity. Being a shallow tank, it goes dry quite early during summer and supports a variety of sandpipers and plovers, while other tanks still have enough water and support ducks. There is still enough vacant land towards the fore shore area which is not planted with trees. No mud lifting activity is seen and brick kilns are not be seen anywhere close to the tank. The tank is totally devoid of any aquatic vegetation. Due to excess monsoon inundation during 1988 the tank bund suffered a wide breach in the middle and it needs to be repaired and strengthened.

9. Rampura Tank

This tank is quite close to Kalkere Tank and is much deeper. The emergent vegetation is mainly grass and Polygonum sp. The mudflats support a large number plovers and sandpipers. The vacant land around the tank has been encroached till the water's edge. Shooting is prevalent to a greater degree here and ducks are most disturbed by shooting.

10.Vartur Tank

Vartur tank is a large tank and its waters are eutrophic and completely green. This tank never goes dry and is perennial. It has a very poor shoreline with vegetable cultivation extending down almost to the water's edge.

Motorised commercial fishing is going on at the tank indicating that there are enough fish to be caught. This is reflected in the unprecedented numbers of Little Grebes (over 550 birds) found here. The large expanse of open water could perhaps attract more migratory ducks but for the plying of boats in the lake. If conditions permit, there is ample scope for development of tree vegetation in standing water.

11. Bidarekere Tank

This tank is situated a little off the Bannerghatta- Anekal Road. This is perhaps the only tank amongst those surveyed where bamboo planting in the foreshore area has been taken up. About twenty species of aquatic birds were recorded during the census.

Since this tank is close to Bannerghatta National Park, it could be developed as a minor migratory waterfowl habitat along with Hennagara.

The disturbance from mudlifting and brick making/tile making industry has to be removed. Though foreshore planting has been done more planting can be taken up to cover the entire foreshore area.

12. Hennagara Tank

This is a large tank situated off the Bannerghatta - Anekal road. This tank is recommended to be made into a migratory waterfowl refuge. Since it is not very far away from Bannerghatta National Park, it could perhaps be a part of a 'Wildlife Complex', along with Bidarekere and Jigani tanks.

Encroachments for cultivation have to be removed and hunting stopped. The bird counts have been good during the census period and this site is probably an important feeding and roosting site for migratory ducks. Over five thousand ducks were recorded here during the census.

Intensive mixed planting of bird attracting tree species should be taken up in the periphery. This should replace the Casuarina monoculture in the area surrounding the tank. Trees in standing water would also help birdlife greately.

13. Jigani Tank

This tank is also on the Bannerghatta - Anekal road and is behind the village the same name. This is a large tank with an extensive shallow bed. A large number of birds were counted here.

Since this tank is quite close to the village which in turn is on the main road, special care has to be taken for vegetating this area. The species need to be necessarily those which form thickets or the trees should be planted close to provide cover. Suitable shrubs should also be planted to cut down visibility through the foreshore. Since the tank seems to be quite flat and shallow, islands could also be developed or alternatively, trees planted in standing water.

14. Taralu, Gopalapura and Tatguppe Tanks

All these three tanks are situated between Bannerghatta range of hills and Kanakapura road. All are secluded tanks with little disturbance. Taralu is a small and beautiful pondlike tank with good anchored floating vegetation. Both Gopalapura and Taralu tanks have a good tree line surrounding the tank, good submerged vegetation and clear waters.

Both these tanks could be left as they are, undisturbed. These two tanks are in stark contrast to the nearby Tatguppe tank which has muddy waters, trees far away from the tank, and almost no aquatic vegetation and very poor birdlife.

15. Lalbagh Tank

Lalbagh tank is the only tank in the heart of the city which attracts waterbirds. Since the early seventies there has been good documentation of the birdlife in this tank. From an earlier record of 31 species of birds the birdlife has drastically fallen to a mere 15. Several changes that have contributed to such a decline in the tank's birdlife are discussed below.

1.A limited growth of water hayacinth in the rear half of the tank supported a healthy population of Purple Moorhens by providing cover, nesting sites and food in the form of tender shoots. In addition birds like Indian Moorhen, Pheasant-tailed Jacana, Coot and Little Grebe used the patches of hyacinth for nesting and the Purple Heron and Pond Heron used the hayacinth growth as foraging substrates. Total removal of the hayacinth growth made most of these species disappear from the tank. However, there seems to be some regrowth at the time of writing this report.

2.The two islets in the middle of the tank were not connected with the main park area several years ago and they had very good shrub cover. These islets which were cut off from the mainland served as a resting area for hundreds of migrant Garganey Teals which could be seen day-roosting along the water's edge around the islets. Besides the shrub vegetation served as nesting substrate for Pond Herons in the early seventies. Also, Marsh Harriers were a common sight before and the rare migrant Osprey has been recorded once at this tank in 1977. The clearing of, and connection of the two islets with the main park area by a land bridge has put an end to all the above bird use of the islets - the Pond Herons no longer nest and the Harriers can no more be seen regularly.

The tank is used every year during the Ganesha festival for immmersion of idols of Lord Ganesha. This excessive dumping of mud/clay every year, appears to have increased the silting of the tank bed and to have made even the deeper zones shallow. As a consequence, whenever there is a reduction in water level, large mud mounds can be seen in several places in the tank.

The inflow of untreated sewage has made the tank waters green and eutrophic. Due to excessive sludge deposition the foreshore area has been silted up and thereby it has further reduced the waterspread and birdlife.

One of the beneficial developments in recent times has been the fencing of the tank which removed disturbance to the tank to a large extent and shoreline planting of trees, though inadequate has provided some perch sites for a few bird species.

Desilting, regulation of sewage inflow, controlled growth of water hayacinth, recreating the islets by removing the land bridge, densely vegetating the islets and total removal of human disturbance to islets may bring back some of the bird species which once regularly frequented Lalbag tank. The tank would then regain its former glory and be of inestimable educational and aesthetic value. Few cities in India can boast of such a large number and variety of birds concentrated at one spot within the city.

The following is the list of water birds recorded at Lalbagh tank. Little Grebe, Pond Heron, Purple Heron, Cattle Egret, Little Egret, Night Heron, Chestnut Bittern, Spotbilled Duck, Garganey, Common Teal, Cotton Teal, Marsh Harrier, Osprey, Whitebreasted Waterhen, Indian Moorhen, Purple Moorhen, Bronzwinged Jacana, Pheasant-tailed Jacana, Coot, Little Ringed Plover, Green Sandpiper, Wood Sandpiper, Common Sandpiper, Snipes,Little Stint, Blackwinged Stilt, River Tern, Pied Kingfisher, Whitebreasted Kingfisher, and Little Blue Kingfisher.

16. Doddabegur Tank

This is one of the larger tanks in the south-east of the city. It is fairly deep when full, with a water expanse of about 165 ha. Considerable area of the tank close to its margins is shallow and supports a rich variety of egrets, herons and waders. During 1988 and 1989 censuses, 525 and 400 birds were counted. Two individuals of the rare White Stork were also sighted during 1988. Human disturbance and activities like mudlifting and brick making are absent. The tank also supports some aquatic vegetation. Planting up of the vacant land around the tank and its foreshore; regulating excessive water outflow for irrigation, protection and preservation of the tank and its environs may make the tank a potential waterfowl refuge.In addition this area is known to be of archaeological/historical importance.

17. Madivala Tank

This is a large tank which faces many serious problems. With adequate protection and some management it can be revived into its former status. Continuous inflow of sewage, mudlifting, brick making, unchecked growth and spread of water hyacinth, unauthorized settlements and human disturbance have posed a serious threat to the habitat and the birdlife of this tank. A variety of birds have reduced in numbers in recent years. The total waterfowl counts for 1987, 1988, and 1989, have been 500, 345, and 302 respectively. In 1989 not even a single duck which once used to be common was recorded. Eutrophication of the tank waters and the subsequent growth of hyacinth have reduced the expanse of open

water. If proper and adequate measures are taken Madivala tank can be an important waterfowl habitat.

18. J.P.Nagar (Bilikanahalli) Tank

This was a very unique tank. Though close to human habitations,it harboured a lot of birds,especially during the migratory season. During the rains,it filled up and became a favorite haunt of birds. Nearly 75% of the waterspread was covered with hyacinth.

Dumping of garbage began about five to six years ago.The species which suffered most was the Pheasant-tailed Jacana. This was one of the two tanks in Bangalore area where breeding has been recorded . There used to be extensive hunting of birds, especially Coots, which also nested here. The tank was recently filled after draining the water and was converted into residential sites. This destroyed an ideal bird habitat and nesting ground.

Birds like Purple Moorhen,Indian Moorhen,Dabchick,Cotton Teal, Spotbilled Duck, Garganey and Marsh Harrier were to be commonly found here.

19. Puttenahalli Tank

This tank is very close to the now filled J.P.Nagar tank and is comparatively larger than it.Hyacinth is the most prominent floating plant.Poaching is prevalent. This tank is equally rich and is the only surviving tank where the Pheasant-tailed Jacana is breeding in Bangalore.This tank is also polluted by sewage.The birds recorded here include Shovellers, Garganeys, Spotbilled Ducks, Cotton, Common and Lesser Whistling Teals, apart from a number of waders and herons.Coots have been seen with young and Indian and Purple Moorhens probably nest here.Interesting counts are 18 Grey Herons and over 100 Dabchicks in the past.Any conversion will destroy this unique bird habitat.

20. Kannehalli and Hirekere Tanks

A deviation on Bangalore-Magadi road takes one to Kannehalli village, situated on the tank's western shore. The tank proper is surrounded by a slightly undulating terrain (small hills) with very poor protection against erosion. However, it is a fairly large and shallow tank with very good prospects for waders and shore zone birds. Downstream is situated a fairly large and deep tank, Hirekere Tank. This complex is rather well protected and free from human interference. It can easily support open water prefering waterfowl.

CHAPTER IV F

PLANKTON OF THE SURVEYED TANKS

INTRODUCTION

The term "Plankton" is derived from Greek meaning "wanderer". Plankton are pelagic organisms which drift freely or capable of swimming weakly, and are at the mercy of waves and currents. They inhabit the "open water zone" between the water surface and the bottom of a waterbody. Most of these organisms are microscopic and hence not known to a lay man. This group has a myriad variety of organisms with fascinating features and survival tactics of their own. The animals and plants of this group are termed "Zooplankton" and "Phytoplankton" respectively. Apart from larger organisms like fish, molluscs, insects and floating and emergent plants in a wetland situation like the tanks, plankton form an important and major compositional part of the foodchain of the ecosystem. Bacteria, fungi and viruses can be planktonic and being much smaller, are classified as nannoplankton or bacterioplankton. In the littoral wet soil zone too, organisms smaller or as large as plankton exist. Apart from these, there are a wide variety of other groups/communities of animal and plant organisms. In short, plankton organisms can belong to different taxa and the classification criteria for their inclusion as plankton is based mostly on their size and mobility. Pelagic plankton as being dealt with presently would not cover organisms larger than 52m and smaller than about 5 mm i.e, those plankters trapped within the plankton net (mesh size: 52μ) during sampling.

Role of plankton

Considering plankton in ecological terms relating to freshwater lentic (i.e impounded or closed) ecosystems, the major processes operational in them are:

a) efficient absorption of the incident solar energy and available nutrients;

b) conversion and consolidation of non-living matter through biological processes into living organic matter by producer plankton;

c) further conversion of producers by herbivores and carnivores into their body matter;

d) decomposition of dead organisms and other organic matter into simpler basic organic, inorganic and gaseous matter; and

e) recycling or resynthesis of matter obtained from the processes (d) into the next cycle of primary synthesis.

Thermodynamic losses between each of the above steps are inevitable and are part of the above natural processes.

The first true bio-synthetic or anabolic (building up) role in any aquatic lentic system like the wetland habitats (tanks) we are considering presently, is triggered by the members of the primary producer (phytoplankton) community, followed by the primary consumer (zooplankton) community. Catabolic (breaking down) role is played mainly by bacterial, fungal and other saprophages.The above processes and the constitution of the planktonic community are highly dynamic and complex but nonetheless fascinating to comprehend. Thus plankton, both as producers and consumers play a pivotal role in transforming the solar energy inputs from one feeding level to the next higher, in the food-chain. This eventually leads to the supporting of larger organisms like molluscs, insects, fishes etc., which in turn support waterfowl.

Therefore the important link between basal abiotic and non-living biotic (organic) matter and living matter in waterbodies is provided by the primary (producer & consumer) plankton organisms. The quantum and more importantly, the diversity of the phyto and zooplankton are determined by the fertility and quality of the water to a large extent. This has been dealt with in chapter IVa. Further, plankton provide considerable quantities of organic matter and nutrients into the nutrient pool of the ecosystem due to their short life cycles.

It is pertinent to point out that the fisheries resources with or without aquaculture practices are undoubtedly a most deserving component linked to wetland resource utilization. These are also supported by the plankton resources present in the wetland. It is necessary that a wholistic or balanced approach in terms of drawing out sustainable yields from such habitats are not delinked, but form part of the modern freshwater fisheries technologies adoptable in the present times. It is thus advisable that for proper management of all prospective resources derivable from wetlands and for their programmed development in the newly emerging contexts, a 'scientific eco-biological management' approach rather than a 'techno-aquacultural management' approach be adopted. In this sphere, the value of the diverse ecological role that plankton play, would have to be given due importance and support.

As a wide range of habitats exist, affected by various aspects including different forms of ecological pressures, so also the composition of the plankton assemblages supported,show wide quantitative variations and diversities. Some of these aspects which affect the distribution and abundance of plankton are bottom sediment criteria, sediment water interactions, water quality criteria, floral and faunal constituents and other ecological features. Such information is however largely not available for local situations and more so for habitats affected by their closeness to large urban areas like Bangalore. There is wide diversity in urban influences which affect these different habitats and hence, the plankton populations.

Further, one of the most significant roles that plankton organisms can play by their abundance, distribution and diverstiy is that they serve as valuable Bio-indicator organisms i.e., they can help in assessing at a fairly primary stage, the health status of any freshwater habitat under consideration. Such attempts to use plankton as bio-indicators to plan habitat management efforts have not yet been adopted on an utilitarian scale in our country. Even the initial attempts if any, are mostly experimental. Such efforts are to be made and put to test at a much faster pace as the situations,now demand.

Need for the study

In the recent past, studies on 'Plankton', 'Limnology' (i.e. the science of freshwaters) and wetland ecosystems, all became inseparable from one another. These studies have been gaining increasing importance as they help us to understand the biotic-abiotic inter-relationships as well as the basic productive features of impounded water bodies.

It was therefore felt necessary that plankton sample collection and analysis also be made a part of the present status study of wetlands (irrigation tanks) in and around Bangalore. However, it has been possible to make only a preliminary effort to scan the samples to draw out at least a representative list of the planktonic organisms inhabiting the surveyed tanks. Later it shall be attempted to analyse the samples in greater detail. This is however out of the scope of the present report. It would be worthwhile to monitor plankton and other aspects of the study, at regular intervals of 2-3/5 years, to draw out management strategies to improve wetland habitats around us.

Methodology

At each of the tanks sampled, plankton collections were made by straining 50 litres of tank water through a Hand-plankton Net (mesh size 52 μ). Each sample was transferred into a labelled 50 ml polyethylene container and fixed with Leugol's Iodine to prevent decomposition. The samples were analysed in the laboratory using a Microscope.From each of the samples 2-3 sub-samples were scanned after spreading them on a glass slide. The plankters were identified using standard keys - mainly Edmondson, 1959 and Needham and Needham, 1962.

Results and discussion

The results of the 'Qualitative plankton analysis' with respect to the 72 tanks are detailed under Tables 6 (Phytoplankton) and 7 (Zooplankton). A few characteristic features concerning the major planktonic groups and a few individual plankters and their associated features are presented below. These shall however be brief and restricted to ecological issues only.

PHYTO-PLANKTON

These are the planktonic primary producer organisms converting radiant solar energy into plant biomass, making use of oxygen, carbon-di-oxide and other nutrients present in the water body by the process of photosynthesis.

Myxophyceae

These are also known as Cyanophyceae and commonly termed blue-green algae. Ecologically, the presence and the quantity of these members in habitats is of great significance. Some of the members of this group are very good bio-indicators. They are not usually found in abundance in healthy habitats, where nutrient supplies are not rich or, are available in balanced amounts. However, major nutrients (like nitrogen and phosphorous) when present in excess (eutrophic condition) can support particular groups or individuals in great abundance resulting in 'blooms'. Usually, these are linked more to algal plankton representatives than to others. Both 'filamentous' and 'non-filamentous' members occur. Ten members have been recognised so far. In nature, nitrogen is an important constituent of all living organisms. Forms like Anabaena, Nostoc and Aphanizomenon sp., as recorded presently and others like Gloeotrichia and Nodularia sp., can directly fix atmospheric nitrogen like leguminous plants can do on land. In water some of them can alternately fix nitrogen from nitrate sources. However, Microcystis and Oscillatoria sp. show dominance when phosphates are in excess. Spirulina sp. is a well known nitrogen fixer and prefers an alkaline medium of 8-9 pH. For these nitrogen fixers to photosynthetize efficiently, iron (Fe) and molybdenum (Mo) in turn are very essential. Eutrophic situations as seen in many tanks around Bangalore, show a predominance of Microcystis sp., the others being Anabaena, Nostoc and Oscillatoria sp., in that order of dominance. Microcystis sp. is also greatly influenced by the rate of supply of ammonia dissolved in the water. Bluegreen algae are the members most often associated with the formation of algal blooms in any waterbody.

Chlorophyceae

These members possess only the green chlorophyll pigment. They are the most diverse group among all the algal groups. 24 members were seen in the present study. Very few of these members can form blooms. However, deficiency of iron can cause blooms of flagellated algae like Volvox, Eudorina and Pandorina sp. etc. Presence of any blue-green algal blooms cause a marked decrease in both diversity and abundance of all other plankton organisms including Chlorophycean members. Many of the Chlorophyceae members are filamentous and some may even need support from substrata. In such cases, the free floating parts form the plankton. Small beautiful organisms with fascinating shapes, the Desmids (Desmidiaceae) also belong to this group. Nine desmid forms were seen in the present study.

Bacillariophyceae (Diatoms)

These also possess the green chlorophyll pigment. They are popularly known as Diatoms and are extremely interesting organisms. They are usually made of two valves and are perfectly symmetric (generally radial). The transparent and delicate valves are made of silica and therefore the silica contents in waters is of extreme importance in regulating their population dynamics. They are however ecologically important as they form the food for many zooplankters. The diversity of forms is high and most fascinating. Twelve forms were identified during the analysis.

Dinophyceae

Showed just one form Ceratium sp., in very low concentrations. It forms a good food resource for zooplankton. Interestingly it has a large flagellum and even feeds on some small phytoplankton organisms and so is classified under protozoans (zooplankton) by some. But it also possesses chlorophyll.

Some forms are attached to various substrates and live as periphytic organisms also. This is most common with diatoms. These provide rich food resources for browsing organisms, of which, many zooplankton compose an important part.

Altogether 56 phytoplankton forms were recorded (see Table 6). In addition were the fungal filaments and plant spore/seed bodies, making the tally 58.

ZOOPLANKTON

These are the primary consumer planktonic organisms. Most of them depend on various phytoplankters for food. Quite a number of them when large, feed on smaller zooplankton to become secondary consumers. Some of them are specifically detritivorus - browsing and feeding on substrate attached organic matter or concentrating on freely suspended organic matter particles or those lying on the floor of the waterbody. The variety and diversity of these organisms is indeed very high and the varied adaptations for such a life are truly fascinating. Many of these organisms are very important as fish food and food for many other aquatic macrofauna.

Protozoa

This group comprises of a very widely diversified set of unicellular organisms. However most protozoans due to their minute size are not collected while sampling the tank water. Most planktonic protozoans are limited to ciliate and flagellate members only. Many a time few protozoans may dominate in specific habitats. The most common examples for such forms are the Difflugia, Arcella, Euglypha, and Centropyxis sp. etc. Protozoans can form ideal food for many higher organisms in

the food chain or food web interlinks. Some other forms may dominate other habitats, based on the nutrients available. Their diversities can also vary greatly with individual habitats. Many protozoans depend on smaller phyto and nannoplankton. Quite a number of them also depend on detrital organic matter particles - suspended or settled. Thirteen protozoans were recorded during the analysis of which, four ciliate members could not be identified.

Rotifera

This is a diverse group of organisms. They are also commonly known as "wheeled animalcules" and have characteristic internal radial rows of jaws serving as feeding mechanisms and ciliary bands and usually a foot for movement. Some of them can also attach themselves easily to substrates. Most of them have a definite shape with a weak exoskeleton frame. The variety of shapes and external attachments (like appendages) are most amazing in their mode of adaptations. It can be said that plankton fauna in most aquatic habitats are dominated by some form of rotifers or the other at any given time. Seasonal and temporal variations are most characteristic. Migration in relation to depth and time are also noticeable. They are the most important group in that they generally form the food organisms for larger zooplankton, as well as for fish and other macro fauna in most freshwater habitats. The rotifers themselves may be both primary consumers dependent on various phytoplankton sources, or secondary consumers, feeding on smaller zooplankton mainly protozoans. In general they are much more mobile compared to protozoans. The group thus forms one of the most important components in the foodchain of aquatic ecosystems. The largest number of forms (22) were observed among the rotifers. Some members are characteristically dominant in cases of polluted waters (especially with domestic effluents). Some Brachionous sp. are especially well known as bioindicators in such situations.

Crustacea

The members of this group belong to the well known Phylum Arthropoda, the largest phylum in terms of species numbers and variety; and among plankton hold the highest position both in terms of systematics and as secondary consumers in the food chain. In healthy habitats wherein external influences of pollution are absent or at least low, members of this group form a sizable population.

The Cladocera include members like Moina sp., Bosmina sp. Daphnia sp., and others. They form the most useful and nutritive group of crustaceans for higher members like fishes in the food chain. Some are even cultured as fish food. They themselves depend on smaller zooplankton and some algal members. However they are highly sensitive to even low concentrations of pollutants. In such cases, there can therefore be a considerable drop in fish populations preferring such zooplankters as food and clean open water habitats. Six cladoceran members were observed.

Five Copepod genera were recorded out of which, the cyclopoid copepod *Mesocyclops leuckarti* was the most common sp. Copepods also form important food organisms for fishes and are also influenced by environmental conditions of the habitats they inhabit. They are more mobile than all other zooplankton with their tougher exoskeleton and long appendages. They are almost wholly dependent on smaller zooplankton organisms for their food needs. They can generally withstand harsher environmental conditions compared to cladocerans.

Ostracods, of which five forms were seen presently are interesting organisms. They appear to have two valves (shells) as exoskeleton, like bivalved molluscs but, are truly arthropods. They prefer the tank bottom and are mostly browsers on recently dead organisms settled on the bottom and probably also on organic matter always available on the tank's floor. They thus have a special niche and also show temporal migrations through the day. They could form important food organisms for some bottom dwelling fishes as well as the other host of mud dwelling organisms like annelids, nematodes, insect larvae and molluscs. Thus their role in the food chain is unique and special in that they can support many other organisms on which larvivorous fish like cat fish and other airbreathing fish depend to a large extent. They are also important in putting organic detritus into the cycle of habitat energetics.

Other members like some insects and insect larvae, are mainly temporary, being plankton only during the early part of their life cycle. Similarly, the free floating eggs of some fishes, crustaceans and other members also form temporary plankton. All these can certainly enter the foodchain and foodweb ramifications of an habitat in various ways, direct or indirect.

In all, 55 forms of zooplankton were seen and these are listed in Table 7.

Conclusion

Some interesting conclusions can be made out from the plankton analysis of the 72 tanks. As far as diversities are concerned, 24.7% of the tanks had more than 20 phytoplankton forms occurring and 30.1% had >15-<20 forms. The ten tanks showing more than 25 forms, were 21, 22, 28, 38, 52, 53, 54, 56, 58 and 61. Yelahanka (tank no.21), showed the highest phytoplankton diversity with 29 forms. 30.1% of the tanks showed a high diversity of blue-green algae with 34.3% in addition becoming almost eutrophic. 48.0% of the habitats showed a dominance by Microcystis sp. and all of these can turn eutrophic i.e., they are under severe pressure from pollution. Only 27.4% show a good diversity of Chlorophycean members. This is also an indicator that only 20 of the 72 tanks are in satisfactory ecological health.

For zooplankton, 39.7% of the tanks showed a good diversity of forms (i.e. >25 forms) and 28.8% recorded >20-<25 forms. Only 20.6% of the habitats, showed a very high diversity of more than 27 forms. These were tank nos. 16, 21, 27, 34, 38, 39, 40, 51, 52, 53, 54, 56,77, 78 and 79. The 3 tanks viz. 34, 52 & 53, showed the highest diversity of 33 zooplankton forms.

In terms of overall diversity considering phyto and zoo plankton together, only 6 (8.2%) of the tanks (nos. 21, 38, 52, 53, 54 and 56) showed high plankton diversities reflecting satisfactory ecological health.

In all therefore, 113 forms of plankton comprising of 58 phyto and 55 zoo plankton were seen during the present analysis. A more detailed analysis could possibly reveal more zooplankton.

CHAPTER V

THREATS, DISTURBANCES AND RECOMMENDATIONS

Wetlands are more vulnerable to accidental and intentional human interference than any other habitat. This is because both water levels and quality can very easily be altered to spoil the life support system of the wetland. Excessive water inflow or outflow, eutrophication through sewage or washed down (leached) fertilisers, industrial effluents or toxic substances with or without synergistic effects, etc., can all impose very severe constraints on wetlands as wildlife habitats. When it becomes unsuitable to wildlife, it is but natural that it becomes unsuitable as wetlands to man also in course of time. This may be directly or through processes like biological amplification. It thus becomes very imperative that we take up the case of the wetlands seriously and in earnest.

This chapter summarises the role and magnitude of some of the more important threats and disturbances our wetlands face. Water quality has not been taken up here since it has been discussed in detail elsewhere.

MUDLIFTING

The Problems

The tank bed silt/mud has been traditionally used as manure and for local constructional purposes on a small scale. With the growth of Bangalore, mudlifting has reached enormous commercial proportions, with the mud being used for making bricks on an industrial scale. The present survey shows mudlifiting activity in as many as 59% of the tanks. It has become rampant, haphazard and indiscriminate. In a few tanks, exploitation of the tank bed is so severe that it has left wide pits up to a depth of 2- 3 metres with vertical walls. The lucrative business of brickmaking has enabled the industry to make use of even power excavators for the purpose.

The Effects

Indiscriminate mudlifting from the tank bed severely affects the tank ecosystem. The vertical walls of the pits lead to enormous silt movement once water starts flowing in during the rains. It renders water turbid (clear water has been recorded in only 14% of the tanks) which in turn brings down the productivity of the tank affecting all aquatic organisms, including fish which could be of food importance. The indiscriminate positioning of the pits leads to the destruction of the shore, the shoreline, the tank bed and the tank itself as a habitat. The vegetation is destroyed and even grass takes some time to re-establish itself in the drier portions. This eventually affects livestock and cattle grazing, not to mention feeding and breeding

sites of birds, affected much earlier. In short, it can be said that mudlifting has reached very grave proportions.

Recommendations

1. There should be open and closed seasons for mudlifting. Mudlifting should compulsorily be restricted to the dry months.

2. The portions of the tanks suitable for mudlifting should be identified and then demarcated into five or six equal sized plots by permanent flagstones. Mudlifting should be allowed on a sequential rotational basis of one plot per year.

3. Pits should not be left with vertical walls but should have sloping walls. This is to avoid the intensity of silt movement when water starts flowing in. The pits should also be interconnected so that water drains into the existing waterbody with the receding water level.

4. All these should be strictly adhered to, to allow the flora and fauna of the tank to survive and perennate, and at the same time allow the tank ecosystem to recuperate through limited successional processes.

5. Since the mudlifting activity is commercial today, a tariff should be collected and suitable legislation enacted for the purpose with the main idea of improving the tank. The tariff should not be less than a rupee per cubic metre of soil/mud/silt dug up or alternatively it could also be auctioned. This should be looked over by the Mandal Panchayats. Fifty percent of the revenue realised should be earmarked to maintain and improve the tank ecosystem.

6. Monitoring of this activity should be by all departments involved : Revenue Department, Minor Irrigation Department and Mandal Panchayats with powers to stay work at the first signs of damage or irregularities.

BRICKMAKING

Brickmaking like mudlifting has reached rampant proportions. It has been recorded in 46% of the tanks in the tank bed area or immediate vicinity of the tank. Apart from necessitating mudlifting for the purpose, brickmaking requires enormous amounts of firewood. Brickmaking activity should be prohibited within 1 km. of the high water level mark used as a baseline. This is to ensure safety of the tank.

ENCROACHMENT OF TANK BEDS

The Problem

Reclamation of the tank bed for uses detrimental to the well being of the tank can be termed encroachments. Apart from mudlifting and brickmaking activities which have already been considered above, encroachments are basically for the purposes of agriculture, human settlements (housing and slums), and road building. In many tanks, cultivation of crops is extended from the neighbouring drylands continuously to the edge of the waterline. Cases where landfilling and walls being built for the purpose have also been come across. The reclamation of Hennur, Agara and J.P.Nagar (Bilikanahalli) tanks for housing are famous now. One part of the Nagavara tank is being reclaimed by landfilling to construct a road. Madiwala tank also has a road running along the length of the tank. All in all, about 44% of the tanks have encroachments.

The Effects

Encroachments not only affect the tank directly but also bring other disturbances closer to the tank. They result in the loss of grazing lands and grasslands. The shore and the vegetation along the tank edge are destroyed. It also opens up opportunities for effluents and raw sewage to be let into the tank directly. All these activities seriously affect the birds especially the shore birds and birds dependent on shore line vegetation. Land filling in even a portion of the tank can lead to severe silting in the rest of the tank bed. This can seriously hamper the ground water recharge through tanks, since both percolation rates and water retention times are drastically affected.

Recommendations

Encroachments need to be removed and adequate immediate protection to the tanks ensured. This should include not only the tank proper but an area outwards from the high water mark, up to say 200-300 m.

The Irrigation and Revenue Departments should take immediate and adequate steps to tackle encroachment problems. Where tankland conversion is involved, technical opinion from the Department of Environment and Forest Department should be considered.

POACHING & HUNTING OF BIRDS

Waterfowl, especially the migratory water birds which are present in our region from about October to April are extensively hunted in our tanks. Clap traps and other suchlike devices, and guns are made use of for the purpose.The clap traps are made using bamboo frames and fish nets. Guns used are of all kinds, from rifles to

muzzle loaders using gunpowder. Actual recorded hunting and that revealed by local enquiries indicate that it is present in about 35% of the tanks. This could even be a conservative underestimate.

Hunting of any kind disturbs the feeding, roosting and breeding birds of the habitat, as they are very sensitive to sound and physical disturbance. Prolonged hunting in a given wetland might progressively drive them away from the site resulting in decreased number of birds in successive years and eventually even forcing them out completely.

Hunting of any kind needs to be stopped. The costs involved in hunting per unit weight of food would be much greater than perhaps growing domestic fowl. Existing laws for the preservation of wildlife which include waterfowl should be given more publicity. On a large scale even the media could be made use of for the purpose. On a local scale, display boards with appropriate warnings and the benefits of having water birds visiting the area could be put up. Monitoring of selected tanks which hold potential should be taken up. Such sites should be declared as protected bird habitats.

SEWAGE AND EFFLUENTS

The problem

During the present survey, presence of sewage and varied degrees of eutrophication have been recorded from 10% of the tanks, while 8% of the tanks had green waters showing high levels of algae or even algal blooms. Other effluents are probably reaching 3% of the tanks.

The effect

Sewage alters the status of the wetland. It brings in enormous quantities of nutrients into the system and enables unregulated growth of algae. Both these raise BOD levels and also result in bad odours coming from the waters. It can also affect the growth of other flora and fauna (including fish and birds).

Other effluents can have other harmful effects depending on the nature of the effluents. Fish deaths under such conditions have been known earlier.

Recommendations

The quality of the water flowing in should be improved and bettered. BOD and suspended solids need to be brought to within acceptable limits. Appropriate technologies and practices need to be employed for the purpose. Inflow of untreated

effluents need to be completely stopped. Indirect inflow of safe, treated effluents could be allowed only if they contribute significantly to the recharge of the tank waters.

There should be a decentralization of the sewage system and only treated sewage should be let out. Raw sewage should never reach the tank directly. The BWSSB should be entrusted to ensure this and the Pollution Control Board should be entrusted to monitor and take action in problems concerning pollution.

A levy could also be collected at the time of creating layouts for sewage treatment plants. It could be based on layout size and be collected for the purpose by, and from appropriate authorities.

GENERAL CONSIDERATIONS

The ultimate aim should also be to bring under control, though it is a difficult process, the siltation of the tank. It is one thing to deepen the tank by removing mud from the tank bed and another to try preventing silting itself. The afforestation of catchment areas would not only help in this regard, but also meet the biomass needs for local uses. Funds earmarked for wasteland development, RLEGP, NREP, CLUMP, DPAP and also Jawahar Rozgar Yojana funds could be used for the purpose. Both the Mandal Panchayats and the Forest Department should be involved; the latter also in technical matters relating to afforestation. Along with silting, reduction of silt movement within the tank is also important. Reducing water inflow velocities while maintaining the inflow might help. The advice of experts in the line may be taken.

CHAPTER VI A

CREATION OF BIRD REFUGES

Irrigation tanks can be made more attractive to birds by providing suitable nesting, feeding and resting sites. The following deal with such possible measures that can turn a promising tank environs into a potential bird refuge.

1. CREATIONS OF ISLANDS FOR BIRDS

Small islands can be created in the tanks, close to the deep water area for birds to rest, nest and feed. Planting them with suitable tree species would provide nesting and roosting sites for egrets, herons, cormorants and such other water birds.

These islands should be planted with species that can withstand water stagnation. The species should be such that they grow to different heights. For example, Terminalia arjuna, Salix tetrasperma, Acacia nilotica and Pandanus species would be a good combination. The pattern of such a planting is illustrated in fig.4. It is advisable to have Pandanus planted in the outermost region on the island. The islands should have a firm foundation in the tank bed. This can be done by having a circle of closely spaced boulders whose bases are well inside the tank bed (Fig 3). The area inside this circle of boulders should be filled with small rocks and soil, so that a raised mound would result. The surface of the island should be raised at least 1 m above the highest water level in the tank. The islands should not be less than 100 sq.m. in area. In large tanks several long sand bars can be created between the deep and shallow water zones to provide resting place for waders, egrets, herons and ducks.

2. DEVELOPMENT OF FORESHORE AREA OF THE TANK

The foreshore area should be densely planted with suitable species. Inside a dense stand of Acacia several other water tolerant species can be planted. Along the water's edge bamboo clumps can be established on raised soil mounds.

3. DEVELOPMENT OF VACANT LAND AROUND THE TANK

The vacant area around the tank above the high water mark should be developed into a wooded area with abundant shrub cover. This may attract a number of passerine and non-passerine bird species. The tree and plant species selected should provide abundant nectar and fruits. It is advisable to plant a few tall species (like Millingtonia hortensis, Casuarina equisetifolia, Eucalyptus tereticornis) that may provide rest- sites for several birds of prey like eagles, hawks, falcons and kites.

4. OTHER MEASURES WHICH COULD BE TAKEN IN SUCH SELECTED TANKS

1. The tank and its surroundings should be protected from human disturbance and other forms of encroachment.

2. Fishing and commercial fish culture should be prohibited.

3. Seeding the tank with fishes that grow to a length of 10-15 cm should be an annual feature.

4. Irrigation outlets should be covered with a mesh to prevent the escape of fishes.

5. The growth and spread of water hyacinth should be controlled.

6. Boating inside the tank should be banned.

7. A few watch towers along the water edge on the sides could be constructed.

8. The tank and its surroundings should not be open for tourists for at least 5 years after all the developmental activities are complete.

CHAPTER VI B

VEGETATING THE WETLANDS

a. Aquatic vegetation

Some of the aquatic plants which could be introduced into tanks are listed below with comments wherever applicable. Plant introduction needs great care that conditions in the tank do not turn these plants into weeds. In the case of emergent species,the time of planting might be critical considering the seasonal change in water levels. But the best way of growing plants in waters which have still not been rendered eutrophic is by protecting the area and by vigorously restricting weed clearing and plant harvesting. This would let the aquatic flora develop naturally. It would be advisable to identify plants which are fairly common to the tanks of a common valley and introduce of such common species in suitable areas within each of the tanks.

Water logged zone

Typha sp. - in patches only.

Cyperus sp.

Polygonum sp.

Ludwigia sp.

Scirpus sp.

Flooded or inundated zone

Aponogton sp.

Trapa sp.

Potomogeton sp.

Utricularia sp. - in small pockets

Hydrilla sp.

Chara sp. - growth could be vigorous as seen in some tanks

Nitella sp.

Nymphaea sp.

Nelumbo sp.

Open waters

Lemna sp.

Spirodela sp.

Wolfia sp.

Azolla sp.

Eicchornia crassipes - In oligotrophic or distrophic waters only; could become a weed in eutrophic waters (but could be used for waste water treatment).

b.Trees for foreshore planting

Tree species can be roughly grouped under three categories for the purposes of foreshore afforestation. The first group would comprise of species and genera which could withstand flooding and inundation.(These have been marked with an 'F' in the list).The second group would comprise of those that withstand waterlogging (marked with a 'W'). The third group would be those that are planted in areas surrounding the tank,on dry ground not subjected to inundation,flooding or waterlogging. The assigning of the species and genera to the various groups might have to be modified with experience.

Many of the river bank species have been used successfully for afforesting foreshores subject to inundation. So a general list of riverbank species has been included with the hope that with further trials,more species could be found useful for the purpose. The ability of species,which essentially grow in such habitats in the wet forest areas,to grow in our dry conditions also has to be investigated.

The list comprises of essentially Indian genera and species found in the peninsula. But it also includes a few exotics which have been introduced widely away from their native areas.

Saplings used for foreshore afforestation should be sufficiently tall so that they are not completely submerged in standing water. Planting on raised mounds would also be helpful. If cuttings are used,they also should be large sized(e.g. Salix sp.).

Under the first category mentioned above,if Mangrove species could be introduced with success into the tank,they would perhaps be the only group which would have a probability of regenerating in standing water.

Littoral species also could be tried since they would also be able to tolerate salty or saline situations with waterlogging.Tanks with continued inflow of sewage accumulate salts,especially sodium chloride.

Acacia nilotica(W,F)

This species may not survive prolonged inundation. A thorny species affording excellent protection to birds. Withstands extreme drying and waterlogging.

Ailanthus altissima(W)

Can grow in swampy area. It is a subtropical-temperate species,but how well it grows in truly tropical areas is unknown.

Anthocephalus cadamba(W)

A riverbank species supposed to do well in water-logged areas.

Bamboo(W,F):Bambusa sp; Dendrocalamus sp.

These provide good perch sites for birds.

Barringtonia acutungula(F)

Grows naturally on riverbanks, etc. Has been used extensively for planting in wet areas.

Casuarina equisetifolia(W)

A coastal and arid zone species introduced into a wide variety of habitats.Can withstand partial waterlogging for a time. **C.glauca** grows on saline and swampy ground,tidal flats and on heavy soils.

Dalbergia sissoo(W,F)

Found in and along the beds of streams and rivers. Needs protection against fire and animal browsing.

Eucalyptus camaldulensis(W)

Tolerates periodic waterlogging. Essentially a streambank species.

E.microtheca (W,F)

Typically this species is found in open woodlands,seasonally inundated land around the edges of swamps or lagoons,and on extensive floodplains of inland rivers.

E.robusta(F)

Grows in swamps and on edges of salt-water estuaries and lagoons in its natural habitat. E.tereticornis(W) will tolerate some flooding but not seasonal inundation.

Ficus glomerata(W)

Used for planting in waterlogged and swampy foreshore areas. This riverbank species attracts fruit eating birds and mammals.

Hibiscus tiliaceus(F)

A fast growing salt tolerant evergreen species native to shallow brackish swamps. Planted to prevent erosion on the banks of rivers and reservoirs. The lowest branches bend down,take root and put forth new growth;thus forming extensive tangled thickets. Regenerates through floating seed capsules also.

Lagerstroemia speciosa(W,F)

A riverbank species used widely for wet sites.

Mangroves(F): Avicennia sp., Ceriops sp.,Rhizophora sp., Sonneratia sp., etc.

As mentioned earlier these may hold promise if they are able to grow,survive and regenerate on their own. Repeated plantings to grow more trees may not be necessary in such cases as in other tree species. If grown in standing water,they may afford good sites and protection for birds.

Mangifera indica(W,F)

Mango is known to survive in wet sites and also grow wild along riverbanks. Bees not only collect nectar from flowers but also collect honeydew honey from mango trees. Birds and mammals eat the soft pulp of fruits. Planting of varieties which are not economically important should be undertaken,if at all it is to be planted. The species may serve as a source of attraction for unnecessary human presence.

Melaleuca quinquenervia(F)

Grows down to the sea's edge in its native habitat. Can grow on wet soils even withstanding inundation. Will grow at even high planting densities,is fire resistant,and is short boled in open stands. Seedlings can survive complete immersion for several weeks.

Myristica (Gymnacanthera) (W,F): M.magnifica, M.canerica.

The former produces aerial roots also. Native to swamp forests. Produce arillate seeds which are eaten by birds and mammals.

Pithecellobium dulce(F)

Survives both heat and shade,and is able to grow on seacoasts even with its roots in brackish or salty water.

Pongamia pinnata=Derris indica(F)

Shade tolerant. Grows along tidal streams and rivers and in coastal forests. It is so highly tolerant of salinity that it can survive even with its roots in salt water.

Populus euphratica(F)

A gregarious species of the temperate region but growing in areas with maximum temperature of up to 50°C, can grow on lands that are seasonally flooded. Occurs naturally in soils of up to 3 parts per thousand salt content.

Psidium guajava(W,F)

It is reported to tolerate flooding and grow in areas where drainage is poor.

Salix tetrasperma(W,F)

A riverbank species that can be propagated by cuttings. Dense canopied and traditionally used for planting in wet sites.

Sesbania sp.: Sesbania sesban(F)

Withstands acid soils,periodic flooding and waterlogging. It can endure 0.4-1% salt concentration in the seedling stage and 0.9-1.4% salt concentration at maturity. S.bipinnosa will grow on wet almost water-logged soils S.grandiflora grows on dikes between paddy fields. The Genus contains nitrogen fixing species that fix nitrogen through stem nodules.

Syzygium cumini(F)

Prospers on riverbanks and is known to withstand prolonged flooding. Along with S.operculata, S.travencoricum is known to grow on riverbanks.

Tamarix spp(D,W)

Some tamarisks are among the most salt tolerant trees and in Australia have performed satisfactory in heavy clays that swell when wet and shrink and crack when dry.

Terminalia arjuna(F)

A riverbank species planted extensively. T.catappa could also be tried. The fruits attract bats.

There are many more riverbank and littoral species on which information needs to be collected and trials made. The following are a few of them.

Aegiceros corniculatum

Bridelia (Glochidon) sp., especially B. retusa and B. zeylanicum

Cerbera manghas

Dolichandrone spathacea

Erythrina indica

Exocaeria gallocha

Hopea sp., H. glabra and H. parviflora
Kirganelia reticulata
Lophopetalum wightianum
Madhuca sp., M. wightianum
Melastoma sp.
Nauclea missionis
Stephygne parviflora
Threspesia populnea
Trewia nudiflora and T. polycarpa
Vitex negundo, V. leucoxylon and V. pubescens.

For planting in dry areas surrounding the tank, the following species could be preferred

Salmalia malabarica
Erythrina indica (variegata) - bird pollinated flowers
Butea monosperma
Lantana sp.
Muntingia calabura - for fruits
Zizyphus sp.
Samanea saman (Rain tree)
Tamarindus indica
Ficus mysorensis, F. benghalensis, F. religiosa, F. benjamina
Spathodea campanulata - mynas visit the flowers.
Peltophorum pterocarpum - seeds are eaten by parakeets

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1. OPEN WATER
2. FLOODED/INUNDATED ZONE
3. WATERLOGGED ZONE
4. DRY/MEADOW ZONE

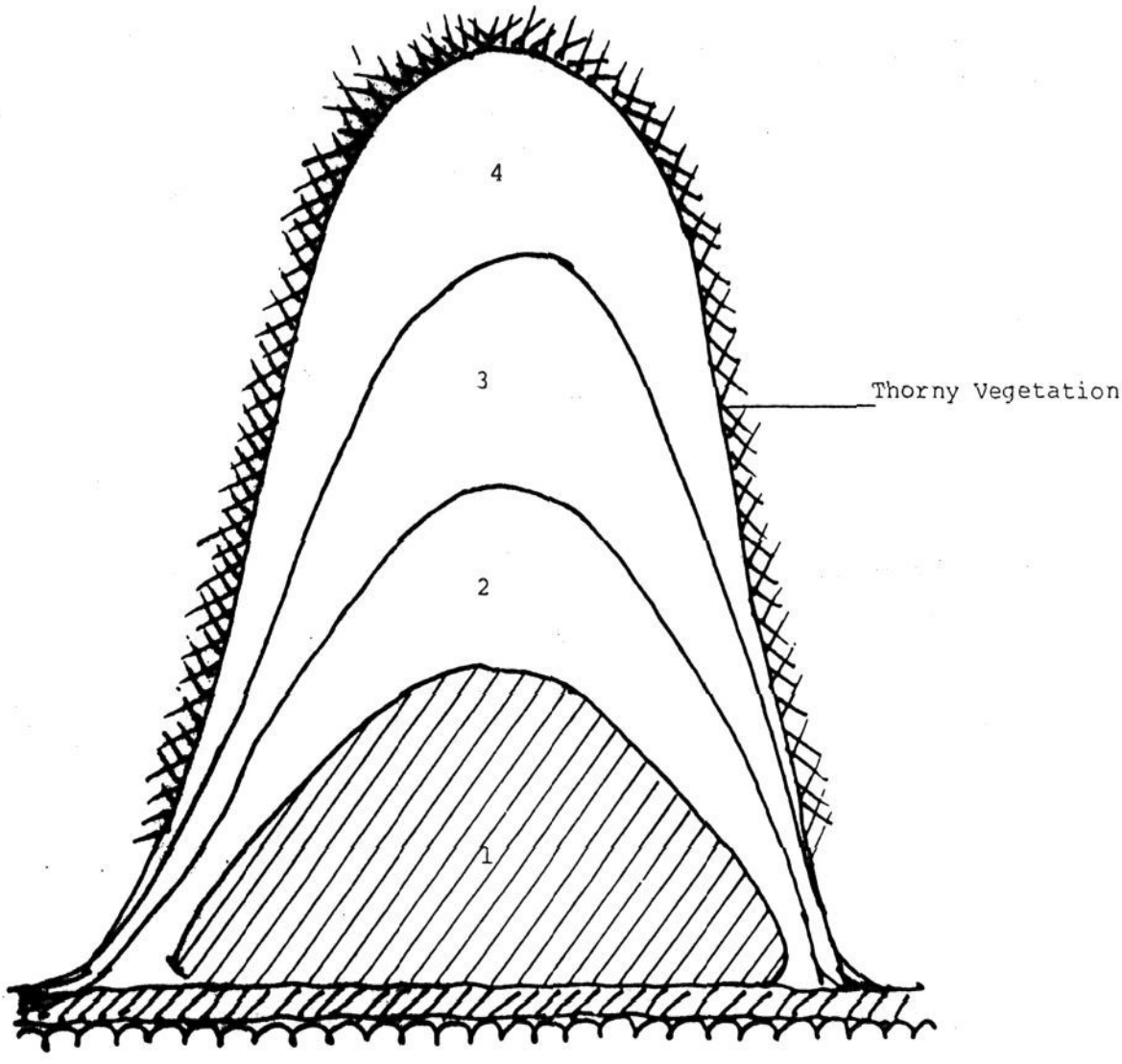


FIG. 1 : ZONATION OF WATER IN AN IRRIGATION TANK

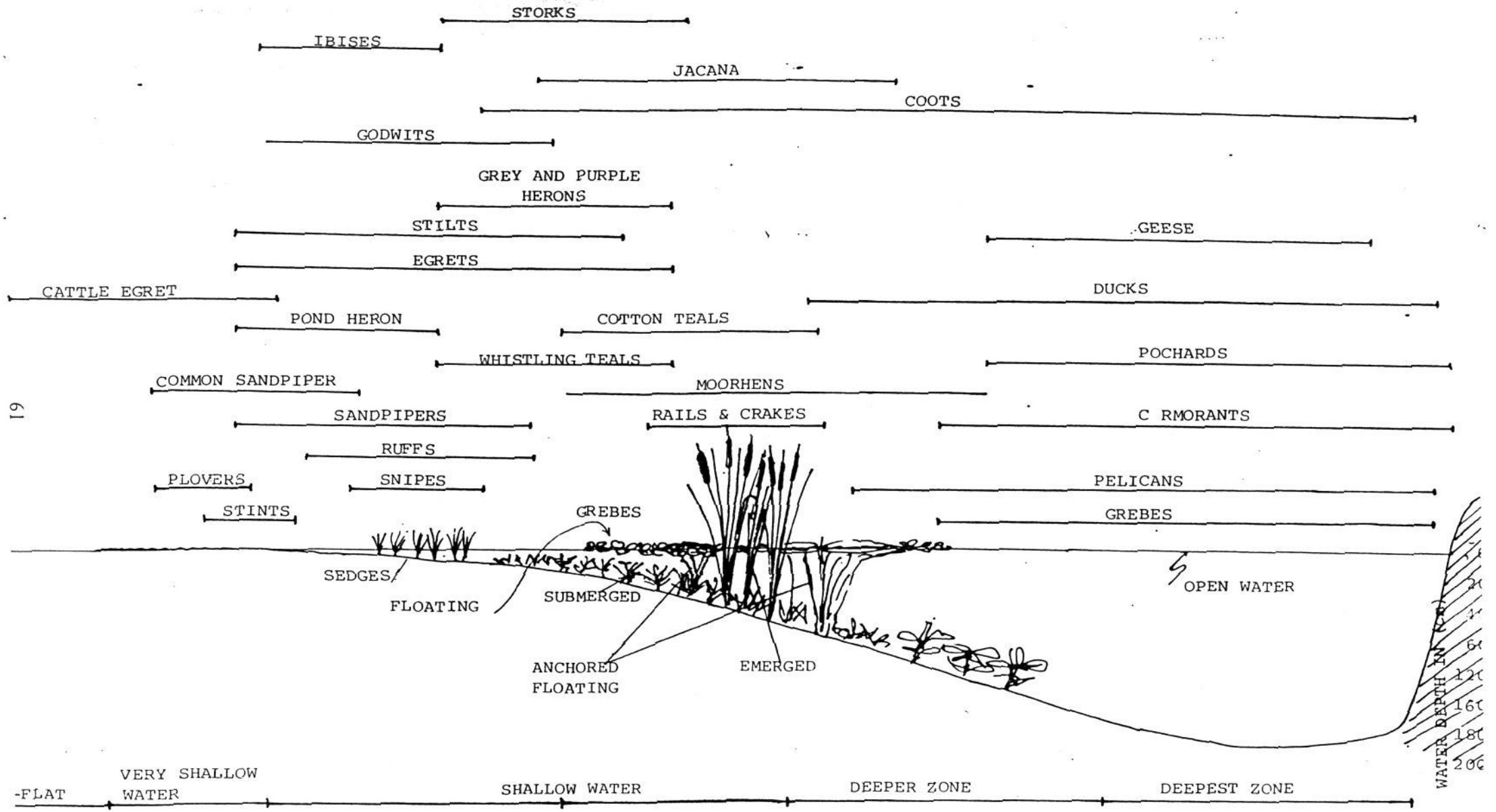
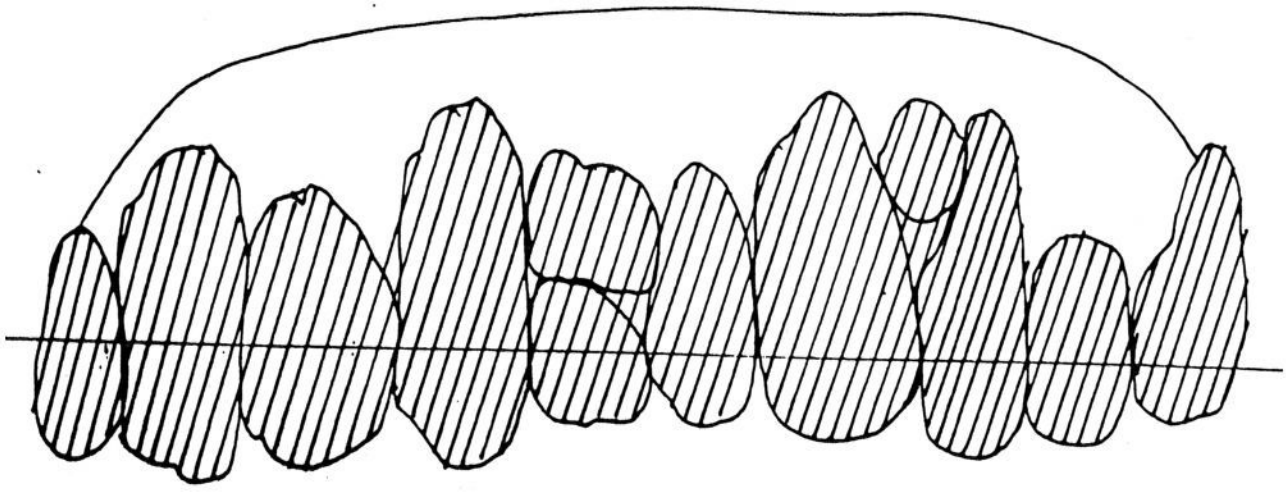
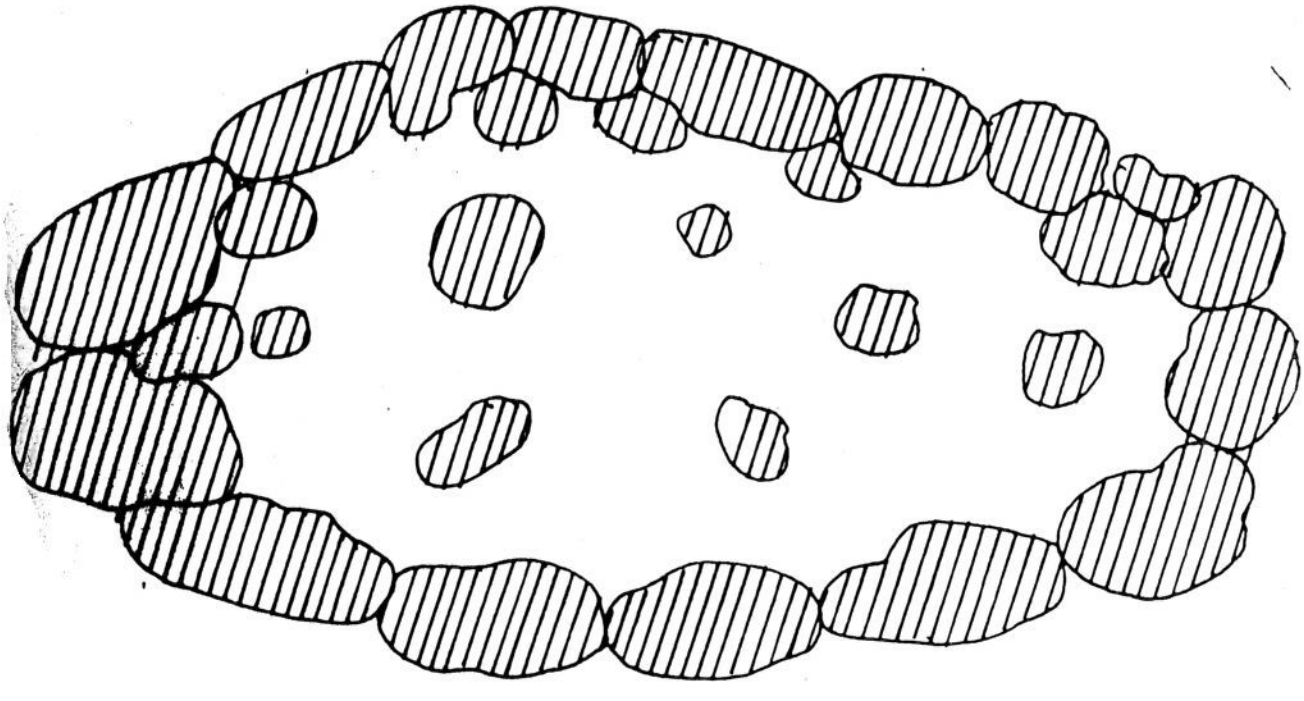


FIG. 2 : A SCHEMATIC DRAWING OF THE UTILIZATION OF IRRIGATION TANKS BY CERTAIN GROUP OF BIRDS



A. SIDE VIEW



B. TOP VIEW

FIG. 3 : STRUCTURE OF A MAN-MADE ISLAND
BEFORE PLANTATION

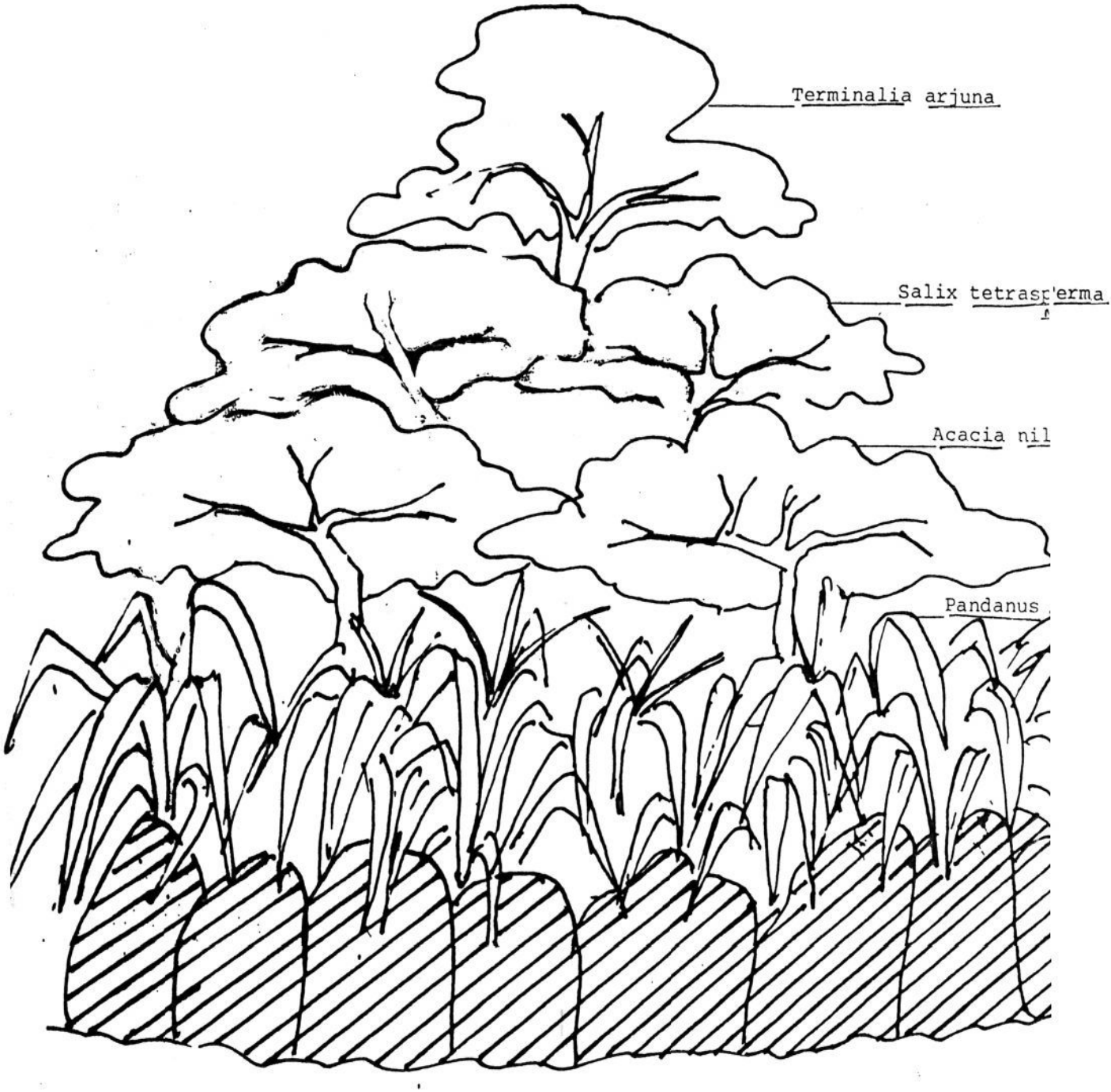


FIG. 4 : DIAGRAMATIC SKETCH OF THE STRUCTURE OF A VEGETATED MAN-MADE ISLAND

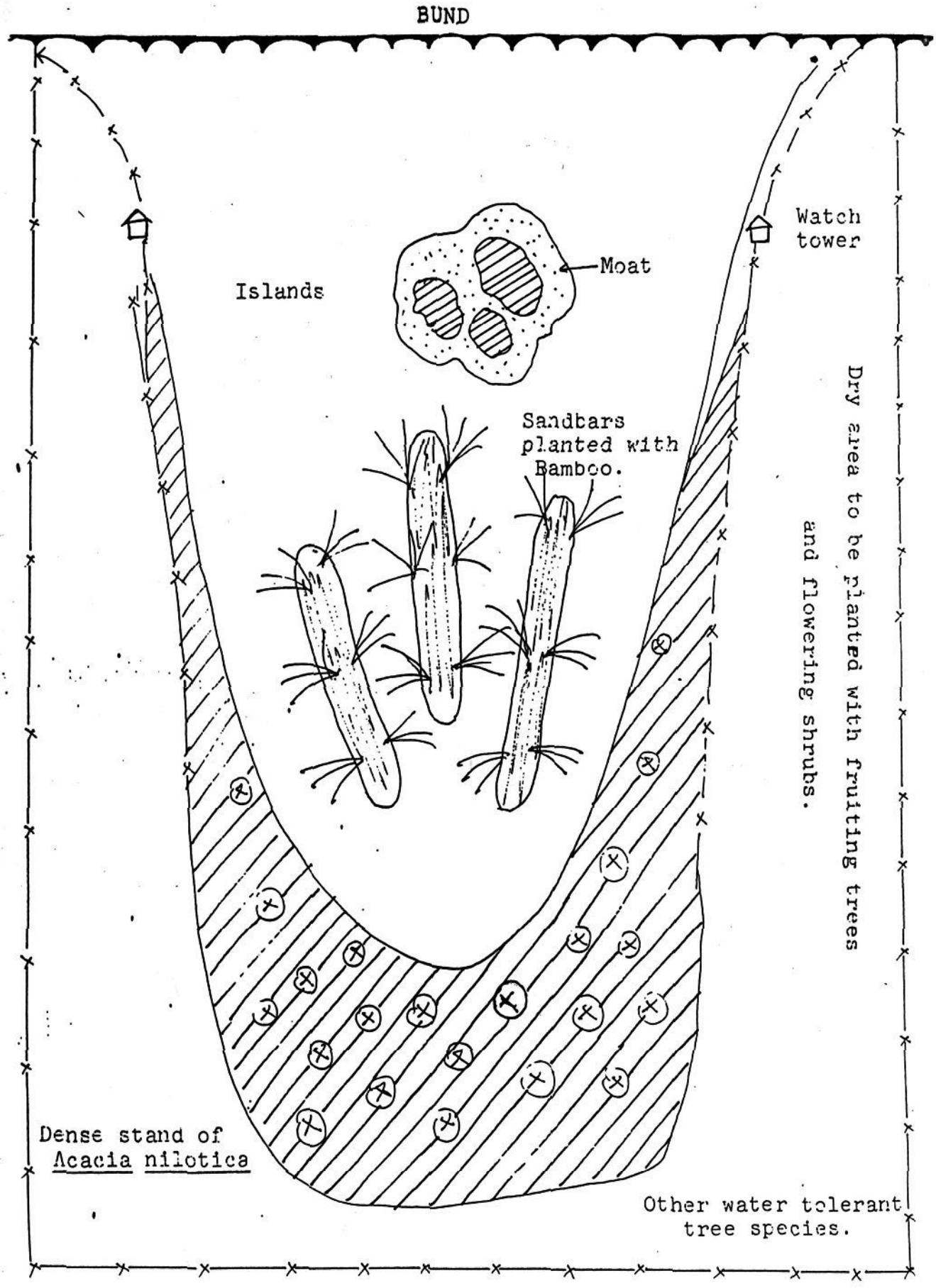


FIG.5: DIAGRAMMATIC ILLUSTRATION OF THE COMPONENTS TO BE INCORPORATED INTO TANKS SELECTED FOR DEVELOPMENT AS BIRD REFUGES.

TABLE 1 CHEMICAL COMPOSITION OF TANK WATERS OF BANGALORE

RANGES	pH	EC mohs/cm at 25deg.C	CATIONS Na+	Ca++	Mg++	K+	ANIONS CO3--	HCO3-	Cl-	RSC	SAR
MAX	10.00	9600.00	61.90	4.40	9.20	4.30	57.00	12.25	49.50	+61.01	71.14
MIN	7.30	132.00	0.00	0.50	0.10	0.03	1.52	0.30	0.20	-0.03	0.00
AVERAGE	8.30	948.60	2.40	1.54	1.00	0.38	10.95	1.95	3.93	+0.46	2.19

TABLE 2. TRACE ELEMENTS CONTENT OF THE TANK WATERS(PPM).

RANGES	BORON	IRON	MANGANESE	COPPER	ZINC
MAX	0.41	16.20	0.55	0.09	0.19
MIN	0.02	0.00	0.00	0.00	0.00
AVERAGE	0.18	2.56	0.07	0.01	0.03
CRITICAL LIMITS IN IRRIGATION WATER	3.00	5.00	0.20	0.20	2.00
% OF SAMPLES BELOW & ABOVE CRITICAL LIMITS	100	80.76 19.23	96.15 3.85	100	100

3. TABLE . CLASSIFICATION OF TANK WATERS OF BANGALORE FOR THEIR DRINKING WATER QUALITY BASED ON I AND ICMR STANDARDS

PARAMETERS mg/lt	CRITICAL LIMITS(IS)	% OF SAMPLES WITHIN CRITICAL LIMITS(IS)	% OF SAMPLES ABOVE CRITICAL LIMITS(IS)	CRITICAL LIMITS(ICMR)	% OF SAMPLES WITHIN CRITICAL LIMITS(ICMR)	% OF SAMPLES ABOVE CRITICAL LIMITS(ICMR)
PH	7.0 - 8.5	73	26.00	6.5 - 9.2	93.50	6.40
DISSOLVED SOLIDS	500.00	73	26.00	1500.00	88.50	11.50
CALCIUM	75.00	96	3.80	200.00	100.00	0.00
MAGNESIUM	50.00	96	3.80	100.00	0.00	
IRON	0.10	12.80	87.00	1.00	53.80	46.00
COPPER	0.05	96.00	4.00	1.50	100.00	0.00
MANGANESE	0.10	89.00	10.20	0.50	98.70	1.30
ZINC	5.00	100.00		5.00	100.00	
DISSOLVED OXYGEN	3.00	100.00		3.00	100.00	
CHLORIDES	200.00	87.00	12.80	100.00	87.20	12.80

4. TABLE . CLASSIFICATION OF TANK WATERS FOR IRRIGATION BASED ON U.S.D.A. STANDARDS.

(Critical ranges are given in parentheses).

QUALITY GUIDELINES:	LOW	MEDIUM	HIGH	VERY HIGH
EC u mhos/cm at 25°C Classes Percent of total	C1(100-250) 17.72	C2(250-750) 52.48	C3(750-2250) 19.20	C4(>2250) 10.08
Sodium absorption ratio Classes Percent of total	S1(<10) 97.4	S2(10-18) 1.2	S3(18-26) 0.0	S4(>26) 1.2
Residual sodium carbonate(RSC) Classes Percent of total	RSC1(<1.25) 92.3	RSC2(1.25-2.5) 3.8	RSC3(>2.5) 3.8	- -
Quality classes to which waters belong Quality classes Percent of total	C1S1 17.92	C2S1 52.48	C3S1 19.2	C4S1,C4S2,C4S4 7.68,1.2, 1.2

LIST OF TANKS SURVEYED

1 CHIKKASANNE
2 SADAHALLI
3 KANNAMANGALA
4 DODDASANNE
5 ANNESWARA
6 CHANNAHALLI
7 CHIKKAJALA
8 DODDAJALA
9 BANDAKODIGENAHALLI
10 BAGALUR
11 GUMMANAHALLI
12 MANCHAPPANAHALLI
13 BUDIGEREAMMANNI
14 TAVAREKERE
15 YELCHEHALLI
16 MUGBALA
17 HOSAKOTE
18 SINGANAYAKANAHALLI
19 HAROHALLI
20 GANTIGANAHALLI
21 YELAHANKA
22 ALLALASANDRA
23 KOGILU
24 JAKKUR
25 RACHENAHALLI
26 KODIGEHALLI
27 HEBBAL
28 NAGAVARA
29 HENNUR
30 KALKERE
31 DODDAGUBBI
32 RAMPURA
33 YELLAMALLAPPACHETTY
34 PUTTENAHALLI
35 J.P.NAGAR [Bilikanahalli]
36 CHIKKA HULIMAVU
37 DODDA HULIMAVU
38 MADIVALA
39 BEGUR
40 CHIKKA BEGUR
41 AGARA
42 DODDANEKKUNDI
43 KAIKONDANAHALLI
44 HALNAYAKANAHALLI
45 TUBARAHALLI
46 KARMALARAM
47 GUNJURPALYA
48 GUNJUR
49 VARTHUR
50 NALLURHALLI-WHITEFIELD
51 BODIGRAMA
52 SAKALVARA
53 MANTAPA
54 BIDAREKERE
55 JIGANI
56 DYAVASANDRA
57 HARAGADDE
58 HENNAGARA
59 GULIMANGALA
60 RAYASANDRA

61 HUSKUR
62 BIDARAGUPPE
63 AREHALLI
64 ATTEBELE
65 DOMMASANDRA
66 YAMRI
67 SARJAPURA
68 DODDATUMKUR
69 JALIGE
70 ARDESHAHALLI
71 KODATHUR
72 MADURE KERE
73 BOMMASHETTYHALLI
74 HUSKUR
75 ALUR
76 NAGARURU
77 NELAMANGALA
78 ARASHINAKUNTE
79 BINNAMANGALA
80 ANCHEPALYA
81 KANNEHALLI
82 HIREKERE
83 KOMMAGHATTA
84 KENGERI
85 TARALU
86 GOPALAPURA
87 TATTAGUPPE
88 TATTAGUNI
89 NEW OBICHUDANAHALLI
90 HAROHALLI
91 KANCHIGARANAHALLI
92 ODKE
93 KALLANADODDI
94 ULSOOR
95 SANKEY
96 LALBAGH
97 YEDIUR

EXPLANATORY NOTES TO TABLES AND ABBREVIATIONS USED

TANKDATA TABLE:

+	=	PRESENT	[> 10%]
++	=	COMMON	[> 35%]
+++	=	ABUNDANT	[> 65%]

COVERAGE:

P	=	PARTIAL COVERAGE
C	=	COMPLETE COVERAGE

WATER:

D	=	DEEP
S	=	SHALLOW
DS	=	DEEP AND SHALLOW

WATER COLOUR:

C	=	CLEAR
M	=	MUDDY
G	=	GREEN
Mk	=	MURKY

*	=	me/lit.
**	=	mg/lit.

PLANKTON TABLES:

P= PRESENT
D= DOMINANT
= ABSENT
?=DOUBTFUL

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	1	2	3	4	5	6	7	8	9	10	11	12	13
LAT DEG. & MIN. -NORTH	13 14	13 13	13 13	13 13	13 13	13 11	13 10	13 10	13 11	13 08	13 08	13 08	13 09
LONG DEG. & MIN. -EAST	77 41	77 38	77 40	77 41	77 44	77 37	77 38	77 39	77 41	77 39	77 41	77 43	77 45
WATER ZONE	DS	S	DS	DS	DS	DRY	DS	DS	DS	S	DS	S	DS
WATER COLOR	M	M	M	M	M		M	M	M	M	M	M	M	M
SEWAGE													
OTHER EFFLUENTS													
MUD FLATS												+	+
MARSH	+	+	+	+	+			+					
EMERGENT VEGETATION		++	++	++	++		+	+	+		++		+
ANCHORED FLOA ING		++	++	++	++		+	+			+	+	+
FREE FLOATING													
SUBMERSED		+	+	+	+			+					
HUNTING	+			+	+					+			+
MUD LIFTING		+		+	+		+			+		++	
BRICK INDUSTRY		+		+	+		+			+			+
LAYOUTS							+	+					
ENCROACHMENTS FOR CULTIVATION				+				+		+	+	+	+
PH	8.3	9.1	8.5	8.0	7.9		7.6	7.8	9.3	8.3	8.5	8.0	8.7
EC	246.00	348.00	354.00	294.00	276.00		576.00	324.00	294.00	234.00	384.00	456.00	288.00
Co3 *	-	-	-	-	-		-	-	-	-	-	-	-
HCo3 *	1.14	0.76	0.95	0.38	0.95		1.14	0.95	0.95	0.57	1.14	1.33	1.52
Cl- *	0.6	0.6	0.6	0.8	0.8		1.0	0.6	0.6	0.6	0.6	0.6	0.6
Ca++ *	1.1	1.5	1.4	1.1	1.3		1.3	1.1	1.3	1.4	1.8	1.2	1.1
Mg++ *	0.7	0.3	0.5	0.1	0.1		0.4	0.9	0.1	0.1	0.1	0.8	0.5
K+ *	0.24	0.25	0.29	0.28	0.27		0.31	0.19	0.17	0.22	0.27	0.26	0.23
Na+ *	0.42	0.59	0.75	0.50	0.40		1.36	0.54	0.47	0.40	0.54	0.68	0.43
RSC *	-0.66	-0.04	-0.95	-0.82	-0.45		-0.56	-1.05	-0.45	-0.93	-0.76	-0.77	-0.08
SAR	0.44	0.62	0.77	0.65	0.48		1.48	0.54	0.56	0.46	0.56	0.68	0.48
USDA	c1s1	c2s1	c2s1	c2s1	c2s1		c2s1	c2s1	c2s1	c1s1	c2s1	c2s1	c2s1
B **	0.10	0.22	0.16	0.25	0.14		0.05	0.16	0.04	0.08	0.10	0.18	0.12
Fe **	9.86	9.37	4.56	1.66	6.13		0.57	0.95	2.11	10.23	1.59	3.69	9.32
Mn **	0.05	0.05	0.05	0.05	0.05		0.05	0.04	0.06	0.06	0.05	0.07	0.07
Cu **	0.01	0.01	0.02	0.01	0.01		0.02	0.01	0.01	0.01	0.00	0.01	0.01

Zn **	0.04	0.06	0.03	0.03	0.02		0.01	0.04	0.02	0.03	0.02	0.02	0.07
Diss oxy **	9.28	8.48	9.32	9.20	9.10		8.70	9.00	9.00	8.96	9.60	8.96	8.60
Diss solids **	157.44	222.72	226.56	188.16	176.64		368.64	207.36	188.16	149.76	245.76	291.84	184.32
Chlorides **	21.30	21.30	21.30	28.40	28.40		35.50	21.30	21.30	21.30	21.30	21.30	21.30
Calcium **	22.00	30.00	49.70	22.00	26.00		26.00	22.00	26.00	49.70	36.00	24.00	22.00
Magnesium **	8.40	3.60	6.00	1.20	1.20		4.80	10.80	1.20	1.20	1.20	9.60	0.60
COVERAGES	P	C	C	P	C		C	C	C	C	P	C	C
LITTLE GREBE	1			1			4	4					
INDIAN SHAG													
LITTLE CORMORANT													
GREY HERON	1		2						1	1			3
PURPLE HERON													
POND HERON	15	11	6	20	65.		5	13	6		3	9	26
LARGE EGRET		3		1			1				1	1	
SMALLER EGRET				1	3		3	1					2
LITTLE EGRET	22	7	5	11	49		9	16	32	35.	6	5	12
CATTLE EGRET	21	20			21			8					
REEF HERON													
OPENBILL STORK													
WHITE NECKED STORK												3	
WHITE IBIS													
BLACK IBIS													
BAR HEADED GOOSE													42
TREE DUCK													
PINTAIL		6-	46		112			1	254				674
COMMON TEAL													
SPOT BILL DUCK		5	2										25
WIGEON									6				
GARGANEY			4	15	162			22	262				2087
SHOVELLER													26
COMMON POCHARD					5		47						
COTTON TEAL					158								
UNIDENTIFIED DUCK													
WHITEBRESTED WATER HEN													
MOORHEN													
PURPLE MOORHEN													
COOT				2									
RUDDY CRAKE													
PHEASANT TAILED JACANA			1										

BLACK WINGED STILT	8		21	30	43		9	25	32	1	24	10	8			
REDWATTLED LAPWING		4	4		14			2		2	2	2	9			
YELLOWWATTLED LAPWING																
LITTLE RINGED PLOVER		3			101			2		14		20.	7			
KENTISH PLOVER										3			4			
BLACK TAILED GODWIT					2											
REDSHANK																
GREENSHANK	1	6	4	3	19		1	5	17.	27	4	39	20			
MARSH SANDPIPER	2	3	5		4			2			5	1.	1			
GREEN SANDPIPER		6	4	5	26		3	5	1.	5		6.	11			
WOOD SANDPIPER		8	12	11	56		4	8	12.	3		3.	16			
COMMON SANDPIPER	1	10	4		30		3	6		5		14.	10			
CURLEW SANDPIPER												8.				
UNIDENTIFIED SANDPIPERS																
PINTAIL SNIPE								3								
FANTAIL SNIPE													5			
UNIDENTIFIED SNIPE		4	27	5	3											
LITTLE STINT										54		114				
TIMMINICK'S STINT																
UNDIDENTIFIED STINT																
RUFF AND REEVE																
BROWN HEADED GULL					1					1	1		19			
INDIAN RIVER TERN					2											

TANK NUMBERS	14	15	16	17	18	19	20	21	22	23	24	25	26
LAT DEG. & MIN. -NORTH	13 08	13 08	13 07	13 05	13 09	13 08	13 08	13 07	13 05	13 06	13 05	13 04	13 04
LONG DEG. & MIN. -EAST	77 56	77 55	77 53	77 46	77 34	77 34	77 36	77 36	77 35	77 37	77 37	77 37	77 34
WATER ZONE	DRY	S	DS	D	DS	S	DS	DS	D	DS	DS	DS	DS
WATER COLOR		C	MK	M	C	M	M	M	MK	M	M	M	M
SEWAGE									+				
OTHER EFFLUENTS								?					
MUD FLATS		++	+							+		+	
MARSH			+			+		+			+	+	
EMERGENT VEGETATION		+	+			++		++	+			+	++
ANCHORED FLOA ING			+			+		++			+		
FREE FLOATING				+				+	++		++		++
SUBMERGED			++		+	++		++			+		
HUNTING					+			+			+		+
MUD LIFTING		+	+		+	+	+	+	+++	+	+	+	++
BRICK INDUSTRY			+		+	+	+	+	++	+	+	+	++
LAYOUTS			+					+	++				++
ENCROACHMENTS FOR CULTIVATION		+	?	+	++		+			+			+
PH		8.3	8.1	8.1	9.0	8.7	8.8	8.0	8.5	7.9	8.0	8.3	8.5
EC		840.00	552.00	420.00	156.00	240.00	252.00	558.00	780.00	900.00	600.00	588.00	720.00
Co3 *		-	-	-	-	-	-	-	-	-	-	-	-
HCo3 *		1.52	1.52	0.57	0.95	1.33	0.57	1.33	2.09	0.95	2.09	1.52	1.71
Cl- *		1.2	0.6	0.4	0.2	0.6	0.6	5.8	1.0	0.8	0.8	2.0	0.8
Ca++ *	-	1.6	1.5	1.4	0.8	1.1	0.7	4.5	1.5	1.2	2.6	1.3	1.4

Mg++ *	0.4	0.4	0.1	0.3	0.7	0.5	3.0	0.8	0.2	-0.1	0.5	0.6
K+ *	0.38	0.21	0.18	0.18	0.17	0.16	0.03	0.26	0.19	0.33	0.27	0.22
Na+ *	0.00	0.59	0.59	0.17	0.37	0.52	0.00	1.74	0.78	1.08	0.80	1.27
RSC *	-0.48	-0.38	-0.93	-0.15	-0.47	-0.63	-0.47	-0.21	-0.45	-3.11	-0.48	-0.09
SAR	0.00	0.61	0.68	0.23	0.39	0.68	6.00	1.63	0.93	0.19	0.80	1.34
USDA	c3s1	c2s1	c2s1	c1s1	c1s1	c2s1	c2s1	c3s1	c3s1	c2s1	c2s1	c2s1
B **	0.27	0.27	0.27	0.32	0.12	0.04	0.08	0.16	0.06	0.20	0.16	0.25
Fe **	1.32	0.35	5.56	2.46	0.81	0.05	0.05	0.14	1.92	0.22	0.08	0.03
Mn **	0.03	0.03	0.03	0.04	0.05	0.06	0.05	0.09	0.06	0.05	0.06	0.05
Cu **	0.02	0.03	0.00	0.01	0.00	0.01	0.01	0.03	0.00	0.01	0.00	0.01
Zn **	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.07	0.02	0.08	0.01
Diss oxy **				10.20	10.06	11.64	9.20	15.00	9.68	9.60	9.00	9.40
Diss solids **	537.60	353.28	268.80	99.84	153.60	161.28	357.12	499.20	576.00	384.00	376.32	460.80
Chlorides **	42.60	21.30	14.20	7.10	21.30	21.30	205.90	35.50	28.40	28.40	71.00	28.40
Calcium **	32.00	30.00	28.00	16.00	22.00	14.00	90.00	30.00	24.00	52.00	26.00	28.00
Magnesium **	4.80	4.80	1.20	3.60	8.40	0.60	36.00	9.60	2.40	1.20	6.00	7.20
COVERAGES	C	C	P	C	P	C	P	C	P	C	C	C
LITTLE GREBE				3	27		1	2		8.	1.	
INDIAN SHAG												
LITTLE CORMORANT				4	11							
GREY HERON		2								2		
PURPLE HERON												
POND HERON	18	9			2	7	7	33	7	29	17.	7.
LARGE EGRET		1			2	2	11		3	1		
SMALLER EGRET	8									1	1.	
LITTLE EGRET	27	11		6	7	11	7	9	9	16	27.	4.
CATTLE EGRET							10	1		16	13.	
REEF HERON												
OPENBILL STORK												
WHITE NECKED STORK												
WHITE IBIS												
BLACK IBIS												
BAR HEADED GOOSE			23									
TREE DUCK												
PINTAIL					148					191		
COMMON TEAL					401							
SPOT BILL DUCK										28		
WIGEON												
GARGANEY							131			265		

SHOVELLER															7				
COMMON POCHARD							28												
COTTON TEAL										2									
UNIDENTIFIED DUCK				6210															
WHITEBRESTED WATER HEN											1								
MOORHEN											2								
PURPLE MOORHEN																			
COOT										15					15				
RUDDY CRAKE																			
PHEASANT TAILED JACANA																			
BLACK WINGED STILT		131		5	6		23	3	6		9.		4.		27		56		94
REDWATTLED LAPWING				6			5	1		1							11		4
YELLOWWATTLED LAPWING																			
LITTLE RINGED PLOVER		106		16					1				8.				30		
KENTISH PLOVER																			
BLACK TAILED GODWIT																			
REDSHANK																			
GREENSHANK		26		6			1			2			18.				2		
MARSH SANDPIPER		85		19						1					28		14		2
GREEN SANDPIPER		18					4		1	3	1		3.		18		14		3
WOOD SANDPIPER		11		32	27		14	1	1		11				3		32		4
COMMON SANDPIPER		12		26			2	4	3		1		1.		6		3		2
CURLEW SANDPIPER																			
UNIDENTIFIED SANDPIPERS																			
PINTAIL SNIPE				11									1.						
FANTAIL SNIPE											4								
UNIDENTIFIED SNIPE				1	45										6		3		
LITTLE STINT		922		1													3		
TEMMINICK'S STINT																			
UNDIDENTIFIED STINT																			
RUFF AND REEVE		5																	
BROWN HEADED GULL		10																	
INDIAN RIVER TERN							2	2											

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	27	28	29	30	31	32	33	34	35	36	37	38	39
LAT DEG. & MIN. -NORTH	13 03	13 03	13 02	13 03	13 04	13 03	13 02	12 54		12 53	12 52	12 54	12 52
LONG DEG. & MIN. -EAST	77 35	77 36	77 38	77 40	77 40	77 41	77 44	77 35		77 36	77 36	77 37	77 38
WATER ZONE	DS	DS	S	S	DS	DS	DS	DS	DRY	S	D	DS	DS
WATER COLOR	G	G	MK	C	M	M	C	MK		M	M	G	M
SEWAGE	++	++	++					+				++	
OTHER EFFLUENTS	+		?				++	?				?	
MUD FLATS			++	++		+					+		+
MARSH		+				+	+	+				+	
EMERGENT VEGETATION	+	++			+	++	++				+	++	
ANCHORED FLOA ING					+	+	+					+	
FREE FLOATING	++	++	++		+	+		+				+++	
SUBMERGED					+		+	++				++	
HUNTING	+	+		+	+	+	+	+				++	
MUD LIFTING		+	+		+	+	+			++	+	+	
BRICK INDUSTRY		+			+	+	+				+	+	
LAYOUTS		+	++				+	+	+++			++	
ENCROACHMENTS FOR CULTIVATION		+			+	+		+			+	+	
PH	7.4	7.5	8.7	8.5	9.1	8.5	8.5	7.9		7.6	8.5	8.7	7.5
EC	2100.00	2400.00	5600.00	4440.00	264.00	3000.00	1440.00	2700.00		600.00	498.00	3000.00	336.00
Co3 *	-	-	-	-	-	-	-	-		-	-	1.90	-
HCo3 *	4.37	5.70	12.35	3.61	0.95	3.42	2.85	5.89		1.33	2.09	0.57	1.33
Cl- *	0.8	0.6	9.6	5.8	0.4	4.0	2.0	2.4		0.8	0.4	44.5	0.6
Ca++ *	1.5	3.7	2.2	2.6	0.3	1.4	3.2	3.7		1.3	1.3	4.4	1.2
Mg++ *	1.8	1.5	4.2	2.0	0.2	3.0	0.8	2.3		0.6	0.4	1.9	0.8
K+ *	0.77	0.87	4.30	1.02	0.18	0.90	0.41	1.02		0.25	0.21	0.31	0.13
Na+ *	0.26	5.20	24.70	14.40	0.56	3.56	3.13	5.91		1.36	0.99	0.21	0.82
RSC *	1.67	0.20	5.90	-0.99	-0.35	-6.98	-1.25	-0.11		-0.57	0.39	-0.03	0.03
SAR	6.22	3.13	13.79	9.60	0.86	4.19	2.24	3.42		1.40	1.07	0.19	1.01
USDA	c3s1	c4s1	c4s2	c4s1	c2s1	c4s1	c3s1	c4s1		c2s1	c2s1	c4s1	c2s1
B **	0.10	0.04	0.12	0.02	0.18	0.02	0.10	0.06		0.30	0.25	0.02	0.22
Fe **	0.14	0.03	0.05	0.22	1.73	0.00	0.05	0.57		0.35	3.97	0.32	1.43
Mn **	0.21	0.05	0.06	0.05	0.04	0.04	0.01	0.26		0.05	0.06	0.14	0.01
Cu **	0.03	0.01	0.01	0.01	0.00	0.00	0.01	0.01		0.01	0.00	0.00	0.00
Zn **	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.02		0.03	0.01	0.03	0.02
Diss oxy **	9.80	25.00	3.30	15.12	10.52	9.60		8.60		10.80	10.00	14.80	11.00

Diss solids **	1344.00	1536.00	3584.00	2841.60	168.96	1920.00	921.60	1728.00		384.00	318.72	1920.00	215.0
Chlorides **	28.40	21.30	340.80	205.90	14.20	142.00	71.00	85.20		28.40	14.20	1579.75	21.3
Calcium **	30.00	74.00	44.00	52.00	18.00	49.70	64.00	74.00		26.00	26.00	88.00	24.0
Magnesium **	21.60	18.00	50.40	24.00	2.40	10.80	9.60	27.60		7.20	4.80	22.80	1.2
COVERAGES	C	P	C	C	C	C	P	C		C	C	P	
LITTLE GREBE								56					8
INDIAN SHAG													
LITTLE CORMORANT													
GREY HERON	1					4					3	2	
PURPLE HERON	2	1										3	
POND HERON	4	31	28	3	4	24	13	43		18	11.	61.	14
LARGE EGRET						3	2						1
SMALLER EGRET					2	2	2	1					1
LITTLE EGRET	4	2	8	7	15	45	4	5.		3	9	1	3
CATTLE EGRET	548	56					1	52			1.	52	1
REEF HERON													
OPENBILL STORK													
WHITE NECKED STORK													
WHITE IBIS													
BLACK IBIS													5.
BAR HEADED GOOSE													
TREE DUCK													
PINTAIL					45		10	11.					
COMMON TEAL					64								
SPOT BILL DUCK													
WIGEON													
GARGANEY								178					
SHOVELLER						11		123.					
COMMON POCHARD													190
COTTON TEAL							4						
UNIDENTIFIED DUCK							2800	17					
WHITEBRESTED WATER HEN													
MOORHEN													
PURPLE MOORHEN	24	32						6				3	
COOT	2	1					9	6				3	
RUDDY CRAKE												1	
PHEASANT TAILED JACANA								24					
BLACK WINGED STILT	20	20	557	169	59.	249		15		17	10	28.	104
REDWATTLED LAPWING		1			5.	14	2	6			3	2	3
YELLOWWATTLED LAPWING											-		
LITTLE RINGED PLOVER		4	24	159	4.	43		1			143		1

KENTISH PLOVER			11	190									4			
BLACK TAILED GODWIT					123	6										
REDSHANK					3											
GREENSHANK				3	33	30	4					2			4	
MARSH SANDPIPER		2	20.	272	46	32							6		8	
GREEN SANDPIPER		5		10	11	10	1	3				8	5		7	
WOOD SANDPIPER		68	27.	40	44	26		6				5	26			
COMMON SANDPIPER	1	1	15.	2	8.	6	6			5		16			7	
CURLEW SANDPIPER																
UNIDENTIFIED SANDPIPERS		33								1					14	
PINTAIL SNIPE										7		3				
FANTAIL SNIPE			2			34										
UNIDENTIFIED SNIPE								3				2			2	
LITTLE STINT			195	671									100		5	
TIMMINICK'S STINT																
UNDIDENTIFIED STINT																
RUFF AND REEVE			10	104		2										
BROWN HEADED GULL						22.									5	
INDIAN RIVER TERN																

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	40	41	42	43	44	45	46	47	48	49	50	51	52
LAT DEG. & MIN. -NORTH	12 53	12 55	12 58	12 55	12 54	12 44	12 54	12 55	12 55	12 57	12 58	12 49	12 49
LONG DEG. & MIN. -EAST	77 38	77 39	77 46	77 40	77 41	77 58	77 43	77 43	77 44	77 44	77 44	77 36	77 37
WATER ZONE	DS	S	S	S	DRY	DRY	DRY	DRY	DRY	D	DS	DS	DS
WATER COLOR	M	M	M	M						G	M	M	C
SEWAGE		?								++			
OTHER EFFLUENTS		?								?			
MUD FLATS	+			++							+		+
MARSH		?+	+							+			
EMERGENT VEGETATION		+	+	+						+		+	
ANCHORED FLOA ING													+
FREE FLOATING		+								+			+
SUBMERGED												+	++
HUNTING		?								+	+		
MUD LIFTING	+		++	+	++		++	++	++		+	+	+
BRICK INDUSTRY	++		+		++				+		+	+	+
LAYOUTS	++	++	+							+	+		
ENCROACHMENTS FOR CULTIVATION	+	+			+		++			++		+	+
PH	7.4	7.9	8.6	8.0						8.0	8.0	8.5	8.4
EC	600.00	2340.00	1620.00	960.00						2040.00	360.00	228.00	270.00
Co3 *	-	1.52	-	-						-	-	-	-
HCo3 *	1.71	4.34	2.85	1.14						6.08	1.90	0.57	0.95
Cl- *	0.8	49.5	1.2	2.2						2.2	0.6	0.4	0.6
Ca++ *	1.7	2.2	1.9	1.4						3.9	1.1	1.6	0.5
Mg++ *	0.2	2.9	0.8	0.4						1.6	0.2	0.2	0.7
K+ *	0.23	0.72	0.29	1.14						0.62	0.17	0.10	0.08
Na+ *	1.57	0.29	2.09	2.61						5.91	0.66	0.59	0.71
RSC *	-0.19	0.74	0.15	-1.06						4.18	0.60	-1.23	-0.25
SAR	1.55	0.18	1.80	2.49						7.29	0.81	0.66	0.92
USDA	c2s1	c4s1	c3s1	c3s1						c3s1	c2s1	c1s1	c2s1
B **	0.30	0.16	0.18	0.02						0.16	0.20	0.16	0.27
Fe **	6.29	0.84	0.27	1.62						0.05	11.66	1.86	0.46
Mn **	0.03	0.10	0.00	0.06						0.18	0.08	0.00	0.05
Cu **	0.02	0.09	0.00	0.01						0.02	0.04	0.00	0.00
Zn **	0.05	0.04	0.01	0.01						0.01	0.06	0.02	0.01
Diss oxy **	11.80	20.80		12.20						10.00		9.80	10.20
*Diss solids **	*384.00*	*1497.60*	*1036.80*	*6144.00*						*1305.60*	*230.40*	*145.92*	*172.80*
Chlorides **	28.40	1757.25	42.60	28.10			-			78.00	21.30	14.20	21.30

Calcium **	34.00	44.00	38.00	28.00						78.00	22.00	32.00	10.00
Magnesium **	2.40	34.80	9.60	48.00						19.20	2.40	2.40	8.40
COVERAGES	C	C	C						C	C	C	C	C
LITTLE GREBE	5									552			14
INDIAN SHAG													
LITTLE CORMORANT												1	3
GREY HERON			4										
PURPLE HERON													
POND HERON	2		70	3						58	4	20	14
LARGE EGRET													
SMALLER EGRET			2							1		3	
LITTLE EGRET			6	3						2	2	3	4
CATTLE EGRET			16	1						24			4
REEF HERON													
OPENBILL STORK													
WHITE NECKED STORK													
WHITE IBIS													
BLACK IBIS													
BAR HEADED GOOSE													
TREE DUCK													
PINTAIL										18			
COMMON TEAL													
SPOT BILL DUCK													
WIGEON													
GARGANEY										58			
SHOVELLER										62			
COMMON POCHARD													
COTTON TEAL													5
UNIDENTIFIED DUCK										65			
WHITEBRESTED WATER HEN													
MOORHEN													
PURPLE MOORHEN										18			
COOT										3			
RUDDY CRAKE													2
PHEASENT TAILED JACANA													
BLACK WINGED STILT	116		50	2								5.	16
REDWATTLED LAPWING	2		6	2						1	6	2.	
YELLOWWATTLED LAPWING											23		
LITTLE RINGED PLOVER	1		20	21						2	12	2	13
KENTISH PLOVER													

BLACK TAILED GODWIT																
REDSHANK																
GREENSHANK	1			10	1								1	1	3	
MARSH SANDPIPER	1			4	6		1						1		5	
GREEN SANDPIPER				12	7							8	3	6	7	
WOOD SANDPIPER	1			15	9							20	8	6	17	
COMMON SANDPIPER	4			13	5							1	12	5	13	
CURLEW SANDPIPER																
UNIDENTIFIED SANDPIPERS																
PINTAIL SNIPE																
FANTAIL SNIPE																
UNIDENTIFIED SNIPE				2								2	3	10	19	
LITTLE STINT	11															
TIMMINICK'S STINT																
UNDIDENTIFIED STINT																
RUFF AND REEVE																
BROWN HEADED GULL																
INDIAN RIVER TERN																

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	53	54	55	56	57	58	59	60	61	62	63	64	65
LAT DEG. & MIN. -NORTH	12 48	12 48	12 47	12 46	12 45	12 47	12 51	12 52	12 52	12 48	12 46	12 46	12 52
LONG DEG. & MIN. -EAST	77 36	77 37	77 38	77 38	77 39	77 40	77 42	77 41	77 43	77 47	77 46	77 47	77 45
WATER ZONE	S	DS	DS	S	DS	DS	S	DS	S	DRY	DS	DRY	DRY
WATER COLOR	C	M	C	C	C	M	M	M	M		M		
SEWAGE													
OTHER EFFLUENTS													
MUD FLATS	+	+	+				+	+	+				
MARSH	+	+	+	+		+			+		+		
EMERGENT VEGETATION	++	++	++	++	+	++			++		++		
ANCHORED FLOA ING	++		+	++	++	+							
FREE FLOATING	+												
SUBMERGED	++	++	++	++	++	++					++		
HUNTING			+		?	+		+					
MUD LIFTING		++			+		+	+	+	+	+	++	
BRICK INDUSTRY		++			+		+	+	+	?	+		
LAYOUTS			+	?	+								
ENCROACHMENTS FOR CULTIVATION		+				++	?	+?					
PH	8.1	8.3	8.5	8.4	7.9	8.4	8.0	7.7	7.9		10.0		
EC	414.00	240.00	282.00	168.00	558.00	420.00	204.00	216.00	288.00		9600.00		
Co3 *	-	-	-	-	-	-	-	-	-		5.70		
HCo3 *	0.95	0.76	0.95	0.57	1.90	1.71	0.76	0.76	1.33		5.57		
Cl- *	0.8	0.6	0.4	0.4	0.8	0.4	0.4	0.4	0.6		7.0		
Ca++ *	1.0	1.3	1.0	0.7	1.2	1.4	0.7	0.9	1.2		1.1		
Mg++ *	0.1	0.1	0.2	0.2	0.9	0.7	0.6	0.3	0.5		0.4		
K+ *	0.11	0.09	0.06	0.03	0.26	0.15	0.25	0.17	0.29		4.00		
Na+ *	1.00	0.66	0.57	0.38	1.06	0.80	0.40	0.26	0.45		61.90		
RSC *	-0.15	-0.64	-0.25	-0.33	-0.20	-0.39	-0.54	-0.44	-0.37		61.01		
SAR	1.35	0.78	0.74	0.57	1.03	0.78	0.49	0.34	0.49		71.14		
USDA	c2s1	c1s1	c2s1	c1s1	c2s1	c2s1	c1s1	c1s1	c2s1		c4s4		
B **	0.41	0.30	0.22	0.22	0.36	0.34	0.16	0.27	0.22		0.27		
Fe **	0.54	0.14	0.41	2.19	0.65	1.05	6.29	3.38	13.20		0.11		
Mn **	0.06	0.06	0.00	0.00	0.00	0.03	0.01	0.05	0.00		0.55		
Cu **	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.01	0.04		0.00		
Zn **	0.02	0.02	0.02	0.04	0.02	0.03	0.04	0.19	0.17		0.04		
Diss oxy **	10.00	9.80	16.00	7.20	10.20	9.00	10.60	12.00	10.80				
Diss solids **	264.96	153.60	180.48	107.52	357.12	268.80	130.56	138.24	184.32		6144.00		
Chlorides **	28.40	21.30	14.20	14.20	28.40	14.20	14.20	14.20	21.30		248.50		

Calcium **	20.00	26.00	20.00	14.00	24.00	28.00	14.00	18.00	24.00		22.00			
Magnesium **	1.20	1.20	2.40	2.40	10.80	8.40	7.20	3.60	6.00		4.80			
COVERAGES	C	P	C	C	C	C	C	C		D				
LITTLE GREBE	10	9	28		11						15			
INDIAN SHAG						1								
LITTLE CORMORANT		2												
GREY HERON			8			1								
PURPLE HERON		1	2											
POND HERON	17	31		21	9	21	4	4	10		13			
LARGE EGRET						2		1						
SMALLER EGRET		3		3	6	15					7			
LITTLE EGRET		5		1	3	23	1	1	1		16			
CATTLE EGRET	1	1				14	1	41						
REEF HERON						1								
OPENBILL STORK						1								
WHITE NECKED STORK			3											
WHITE IBIS						4								
BLACK IBIS														
BAR HEADED GOOSE														
TREE DUCK			58		29									
PINTAIL		1	243			485					1			
COMMON TEAL						322	1	1						
SPOT BILL DUCK						25		3						
WIGEON														
GARGANEY			2		14	62								
SHOVELLER						289								
COMMON POCHARD		4	2			325								
COTTON TEAL	8		127		22						2			
UNIDENTIFIED DUCK			1200			2872								
WHITEBRESTED WATER HEN														
MOORHEN														
PURPLE MOORHEN														
COOT														
RUDDY CRAKE		4	300		1									
PHEASENT TAILED JACANA			2											
BLACK WINGED STILT		15		2	3	41	8		17.00		59			
REDWATTLED LAPWING	5	13		1		3		4						
YELLOWWATTLED LAPWING						1								
LITTLE RINGED PLOVER		7			7		10		7.00		149			
KENTISH PLOVER														

BLACK TAILED GODWIT			8										
REDSHANK													
GREENSHANK		2.				6.	2		17		24		
MARSH SANDPIPER		1			3	2	10	1	3		14		
GREEN SANDPIPER	2	16		2	10	14	1		6		9		
WOOD SANDPIPER		38		4	13	11	1		2		75		
COMMON SANDPIPER		9	2	2	4	14	4	1	4		34		
CURLEW SANDPIPER													
UNIDENTIFIED SANDPIPERS						12							
PINTAIL SNIPE													
FANTAIL SNIPE													
UNIDENTIFIED SNIPE		34			2								
LITTLE STINT							13		32.		136		
TIMMINICK'S STINT													
UNDIDENTIFIED STINT													
RUFF AND REEVE													
BROWN HEADED GULL													
INDIAN RIVER TERN	1	1			1	6							

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	66	67	68	69	70	71	72	73	74	75	76	77	78
LAT DEG. & MIN. -NORTH	12 52	12 52	13 14	13 13	13 14	13 13	13 13	13 08	13 08	13 06	13 06	13 06	13 05
LONG DEG. & MIN. -EAST	77 46	77 47	77 32	77 35	77 34	77 32	77 27	77 25	77 26	77 28	77 26	77 24	77 26
WATER ZONE	DRY	DRY	DS	S	DS	DS	DS	DRY	DRY	DS	S	DS	S
WATER COLOR			M	M	M	M	M			M	M	M	M
SEWAGE													
OTHER EFFLUENTS													
MUD FLATS			+	+		+							
MARSH			+		+		+			+	+		
EMERGENT VEGETATION			+		+	++				++	++	+	++
ANCHORED FLOA ING							++			+		+	+
FREE FLOATING													
SUBMERGED													
HUNTING			++	+	++	+				+			
MUD LIFTING	++			+		+	+				++	+	+
BRICK INDUSTRY				+		+	+				+	+	
LAYOUTS											+	+	+
ENCROACHMENTS FOR CULTIVATION			+	+					+				+
PH			7.5	9.3	7.8	7.7	8.7			8.8		7.7	7.9
EC			474.00	132.00	228.00	336.00	210.00			324.00		720.00	780.00
Co3 *			-	-	-	-	-			-		-	-
HCo3 *			1.90	1.33	1.33	1.52	1.14			1.33		2.28	2.28
Cl- *			0.8	0.2	0.4	0.6	0.6			0.6		1.2	0.8
Ca++ *			1.5	1.0	0.7	1.8	0.7			1.1		1.2	2.4
Mg++ *			0.7	0.5	0.7	0.3	9.2			3.2		1.0	0.6
K+ *			0.29	0.23	0.18	0.15	0.21			0.14		0.80	0.24
Na+ *			0.03	0.04	0.59	0.89	0.31			0.37		1.39	1.37
RSC *			0.30	-0.17	-0.07	-0.58	0.24			-2.97		0.08	-0.72
SAR			0.02	0.05	0.70	0.87	3.29			0.25		1.32	1.12
USDA			c2s1	c1s1	c1s1	c2s1	c1s1			c2s1		c2s1	c3s1
B **			0.10	0.20	0.14	0.20	0.22			0.27		0.25	0.30
Fe **			0.68	16.26	9.91	0.76	12.99			0.16		5.24	1.05
Mn **			0.03	0.04	0.09	0.05	0.06			0.05		0.07	0.07
Cu **			0.01	0.01	0.00	0.03	0.01			0.01		0.02	0.00
Zn **			0.06	0.08	0.04	0.01	0.10			0.01		0.03	0.02
Diss oxy **			9.80	10.80	10.30	18.90	12.00			12.10		9.46	9.26
Diss solids **			303.36	84.48	145.92	215.04	134.40			207.36		460.80	499.20
Chlorides **			28.40	7.10	14.20	21.30	21.30			21.30		42.60	28.40

Calcium **			30.00	20.00	14.00	36.00	14.00			22.00		24.00	48.00
Magnesium **			8.40	6.00	8.40	3.60	110.40			38.40		12.00	7.20
COVERAGES			C	C	P	C	P		C	C		C	C
LITTLE GREBE													
INDIAN SHAG													
LITTLE CORMORANT													
GREY HERON					3	1				1		1	
PURPLE HERON							1						
POND HERON			11	1			22			1		6	1
LARGE EGRET			1		3	1	1						1
SMALLER EGRET			2			1	10						
LITTLE EGRET			13	1			39			10		6	9
CATTLE EGRET							6			22		6	1
REEF HERON													
OPENBILL STORK													
WHITE NECKED STORK						7	1						
WHITE IBIS													
BLACK IBIS													
BAR HEADED GOOSE													
TREE DUCK							1						
PINTAIL			291			5							
COMMON TEAL													
SPOT BILL DUCK													
WIGEON						6	29						
GARGANEY			161							6			
SHOVELLER													
COMMON POCHARD					2		5						
COTTON TEAL													
UNIDENTIFIED DUCK							2065						
WHITEBRESTED WATER HEN													
MOORHEN													
PURPLE MOORHEN													
COOT								1					
RUDDY CRAKE													
PHEASENT TAILED JACANA													
BLACK WINGED STILT				33	6	3	15	48			14		17
REDWATTLED LAPWING				2				10			5		14
YELLOWWATTLED LAPWING													
LITTLE RINGED PLOVER				10			51				9		2
KENTISH PLOVER													

BLACK TAILED GODWIT																	
REDSHANK																	
GREENSHANK				8	3	2	10	5				4			1		
MARSH SANDPIPER				16			10	13				6			1		
GREEN SANDPIPER				10			4	7				18			2		
WOOD SANDPIPER				15	2		5	6				18					
COMMON SANDPIPER				12			8.	15				12.					
CURLEW SANDPIPER																	
UNIDENTIFIED SANDPIPERS																	
PINTAIL SNIPE																	
FANTAIL SNIPE																	
UNIDENTIFIED SNIPE				29				14							2		
LITTLE STINT				68			5										
TIMMINICK'S STINT																	
UNDIDENTIFIED STINT																	
RUFF AND REEVE																	
BROWN HEADED GULL																	
INDIAN RIVER TERN				3								3					

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	79	80	81	82	83	84	85	86	87	88	89	90	91
LAT DEG. & MIN. -NORTH	13 05	13 03	12 58	12 59	12 56	12 55	12 47	12 47	12 46	12 50	12 50	12 41	
LONG DEG. & MIN. -EAST	77 25	77 29	77 29	77 28	77 28	77 29	77 31	77 32	77 47	77 31	77 32	77 28	
WATER ZONE	S	DS	S	S	S	DS	S	DS	DS	DS	D	S	DS
WATER COLOR	M	M	M	M	M	M	C	C	M	M	M	M	C
SEWAGE													
OTHER EFFLUENTS		+									?		
MUD FLATS		+	+		+								
MARSH			+	+			+	+				+	+
EMERGENT VEGETATION		+	+	+			+	+		+		++	+
ANCHORED FLOATING							+					+	
FREE FLOATING		+											+
SUBMERGED				+			++	++				++	
HUNTING			+	+									
MUD LIFTING	(+)	+	+	+	+				?			+	
BRICK INDUSTRY	(+)	+	+	+					+			+	
LAYOUTS		+				+							
ENCROACHMENTS FOR CULTIVATION			+	+	+	+							
PH	8.0	8.1					9.1	9.5	8.8	8.9	8.3	10.1	
EC	720.00	1680.00					408.00	600.00	354.00	168.00	414.00	720.00	
Co3 *	-	-					-	-	-	-	-	2.28	
HCo3 *	1.90	3.04					1.52	2.47	1.71	0.57	1.52	0.38	
Cl- *	0.8	0.8					0.6	0.8	0.4	0.8	0.6	0.6	
Ca++ *	1.5	1.6					0.8	1.2	1.1	1.3	1.1	1.1	
Mg++ *	1.9	3.2					0.8	0.7	0.2	0.9	0.9	0.4	
K+ *	0.32	0.34					0.12	0.08	0.09	0.08	0.17	0.07	
Na+ *	1.36	2.08					1.13	1.70	1.08	0.21	1.22	1.91	
RSC *	-1.50	-1.76					-0.08	0.57	1.11	-5.43	-0.48	1.15	
SAR	1.05	1.34					1.27	1.75	1.21	0.12	1.22	2.19	
USDA	c2s1	c3s1					c2s1	c2s1	c2s1	c1s1	c2s1	c2s1	
B **	0.30	0.04					0.16	0.27	0.20	0.16	0.39	0.30	
Fe **	2.05	0.16					0.08	0.16	1.40	0.95	1.43	0.08	
Mn **	0.07	0.26					0.06	0.06	0.06	0.08	0.05	0.05	
Cu **	0.01	0.01					0.01	0.01	0.03	0.01	0.01	0.02	
Zn **	0.02	0.02					0.01	0.01	0.01	0.05	0.01	0.01	
Diss oxy **	11.40	10.60					12.00	16.40	11.00	11.20	12.40	18.00	
Diss solids **	460.80	1075.20					261.12	384.00	226.56	107.52	264.96	460.80	
Chlorides **	28.40	63.90					21.30	28.40	14.20	28.40	21.30	21.30	

Calcium **		30.00		32.00								16.00		24.00		22.00		26.00		22.00		22.00		
Magnesium **		22.80		38.40								9.60		8.40		2.40		10.80		10.80		4.80		
COVERAGES		C		P		C		C		C		C		C						P		P		P
LITTLE GREBE									2			4								17				5
INDIAN SHAG																								
LITTLE CORMORANT									8			1								9		5		
GREY HERON																								
PURPLE HERON																				1		1		
POND HERON		2				9		18		10		4		4						13				1
LARGE EGRET																								
SMALLER EGRET						1				2				2		1								
LITTLE EGRET		5		3		4		25		2		2		2		1								
CATTLE EGRET				3				11		36										18		3		1
REEF HERON																								
OPENBILL STORK								2														1		
WHITE NECKED STORK																								
WHITE IBIS																								
BLACK IBIS																								
BAR HEADED GOOSE																								
TREE DUCK																								
PINTAIL									3											150		250		40
COMMON TEAL																								
SPOT BILL DUCK																						5		
WIGEON																								
GARGANEY																				93		308		94
SHOVELLER																				4				
COMMON POCHARD																				3				
COTTON TEAL																1				2				
UNIDENTIFIED DUCK																								
WHITEBRESTED WATER HEN																								
MOORHEN																								
PURPLE MOORHEN																								
COOT																								
RUDDY CRAKE																								
PHEASENT TAILED JACANA																								
BLACK WINGED STILT		1						1		39		10		14				4				32		
REDWATTLED LAPWING						7		4		4		10				4								
YELLOWWATTLED LAPWING																								
LITTLE RINGED PLOVER						4		2		34		5												
KENTISH PLOVER																								

BLACK TAILED GODWIT																		
REDSHANK																		
GREENSHANK			1			1	17	9										
MARSH SANDPIPER							20	4			3	1						
GREEN SANDPIPER	1		1			2	16	8	2									
WOOD SANDPIPER	3						19	7	1		2						2	
COMMON SANDPIPER			1		5	3	7	7	1									
CURLEW SANDPIPER																		
UNIDENTIFIED SANDPIPERS																		
PINTAIL SNIPE							1											
FANTAIL SNIPE							4											
UNIDENTIFIED SNIPE	10		1														2	
LITTLE STINT							90	60										
TIMMINICK'S STINT																		
UNDIDENTIFIED STINT																		
RUFF AND REEVE																		
BROWN HEADED GULL																		
INDIAN RIVER TERN	2				2			2										

WETLAND STATUS, BIRD COUNT & RESULTS OF WATER ANALYSIS FOR THE TANKS COVERED.

TANK NUMBERS	92	93	94	95	96	97
LAT DEG. & MIN. -NORTH			12 59		12 57	
LONG DEG. & MIN. -EAST			77 42		77 35	
WATER ZONE	DS	DS	D	DS	DS	D
WATER COLOR	MK	MK	G	G	G	G
SEWAGE			+		++	+
OTHER EFFLUENTS			?			
MUD FLATS					+	
MARSH					++	
EMERGENT VEGETATION				++	+	
ANCHORED FLO RING					+	
FREE FLOATING	+		+		+	
SUBMERGED						
HUNTING					+	
MUD LIFTING	+	+				
BRICK INDUSTRY	+	+				
LAYOUTS						
ENCROACHMENTS FOR CULTIVATION						
PH			7.8	8.4	7.3	7.6
EC			1260.00	1020.00	1380.00	1740.00
Co3 *			-	1.52	-	-
HCo3 *			3.23	0.87	3.04	4.18
Cl- *			30.0	14.0	40.0	43.5
Ca++ *			1.7	2.0	1.8	2.0
Mg++ *			0.1	0.6	0.2	0.1
K+ *			0.54	0.03	0.57	0.41
Na+ *			0.02	0.00	0.02	0.10
RSC *			1.43	-0.21	1.04	2.08
SAR			0.02	0.00	0.02	0.09
USDA			c3s1	c3s1	c3s1	c3s1
B **			0.08	0.22	0.16	0.20
Fe **			0.49	0.32	0.29	0.92
Mn **			0.04	0.14	0.04	0.10
Cu **			0.04	0.00	0.08	0.06
Zn **			0.02	0.05	0.03	0.06
Diss oxy **			20.00	14.48	19.00	17.00
Diss solids **			806.40	652.80	883.20	1113.60
Chlorides **			1065.00	497.00	1420.00	1544.25

Calcium **			34.00	40.00	36.00	40.00
Magnesium **			1.20	7.20	2.40	1.20
COVERAGES	P		C			C
LITTLE GREBE			6	29		
INDIAN SHAG						
LITTLE CORMORANT						
GREY HERON						
PURPLE HERON						
POND HERON			15	7		6
LARGE EGRET						
SMALLER EGRET						
LITTLE EGRET	3		1	1		4
CATTLE EGRET	2					
REEF HERON						
OPENBILL STORK						
WHITE NECKED STORK						-
WHITE IBIS						
BLACK IBIS						
BAR HEADED GOOSE						
TREE DUCK						
PINTAIL						
COMMON TEAL			25			
SPOT BILL DUCK			2			
WIGEON						
GARGANEY			1400			
SHOVELLER						
COMMON POCHARD						
COTTON TEAL						
UNIDENTIFIED DUCK						
WHITEBRESTED WATER HEN						
MOORHEN				5		
PURPLE MOORHEN				6		
COOT				28		8
RUDDY CRAKE						
PHEASENT TAILED JACANA						
BLACK WINGED STILT		6				
REDWATTLED LAPWING						
YELLOWWATTLED LAPWING						
LITTLE RINGED PLOVER						
KENTISH PLOVER						

BLACK TAILED GODWIT							
REDSHANK							
GREENSHANK							
MARSH SANDPIPER							
GREEN SANDPIPER							
WOOD SANDPIPER		3					
COMMON SANDPIPER		3					
CURLEW SANDPIPER							
UNIDENTIFIED SANDPIPERS			1				
PINTAIL SNIPE							
FANTAIL SNIPE							
UNIDENTIFIED SNIPE		6					
LITTLE STINT							
TIMMINICK'S STINT							
UNDIDENTIFIED STINT							
RUFF AND REEVE							
BROWN HEADED GULL							
INDIAN RIVER TERN							

TABLE - 6

RESULTS OF THE PLANKTON ANALYSIS: PHYTOPLANKTON

Tank Nos. :	1	2	3	4	5	7	8	9	10	11	12	13
MYXOPHYCEAE												
Microcystis	P	P	P	P	P	P	P	P	P	P	P	
Anabaena	P		P	P	P							
Nostoc	P			P	P						?	
Spirulina							p				p	
CHLOROPHYCEAE												
Eudorina							p					
Ulothrix	p	p	p	p	p		p			p	p	p
Zygnema	p	p	p	p	p		p			p	p	p
Spirogyra	p		p	p	p	p	p			?	?	p
Chaetophora				p	p	p	p	p	p			
DESMIDIACEAE												
Closteriopsis					P							
Netrium					P		?					
Spirotaenium										?		
Gonatozygon										P		
BACILLARIOPHYCEAE												
Pinnularia-I	P	P	P	P		P	P	P	P	P	P	P
Pinnularia-II	P	P	P	P		P	P	P	P		P	P
Naviculla	P	P	P	P		P	P	P	P	P	P	
Synedra										P	P	P
Nitzschia							P					
DINOPHYCEAE												
Ceratium			?	P								

Tank Nos. :	15	16	17	18	19	20	21	22	23	24	25	26
MYXOPHYCEAE												
Microcystis	?	?		P			P	P	P		P	P
Anabaena	?	?					P	P	P			
Oscillatoria								P				
Nostoc		?	?	P			P	P	P		?	
Merismopedia												
Spirulina	?						P		P			
Lyngbya	P	P	P	P	P	P	P	P	P			
Phormidium		?	?	P	P	P	P	P	P			
Aphanizomenon			P				P	P	P			
Coelosphaerium								P				
CHLOROPHYCEAE												
Protococcus												
Botryococcus												
Synura								P				
Volvox							?					
Eudorina								P				
Pandorina								P				
Pleodorina								P				
Uroglena								P				
Tribonema			P									
Ulothrix	?	P		P	?		P			P	P	P
Microspora												
Zygnema	?	?	?	P	?		P	P	P	P	P	P
Oedogonium												
Spirogyra	P	P		P	?	P	P	P		P	P	
Characium				P			P					
Chaetophora				P			P					
Draparnaldia												
Mougeotia												

Tank Nos. :	15	16	17	18	19	20	21	22	23	24	25	26
Scenedesmus												
Ankistrodesmus								P				
Selenastrum							P	P	P			
Cladophora							P					
Pediastrum							P					
Unid. forms						P						
DESMIDIAOEAE												
Cosmarium							P					
Closterium		P					P			P	P	
Closteriopsis		P								P	P	
Netrium												
Mesotaenium												
Spirotaenium												
Gonatozygon				P			P					
BACILLARIOPHYCEAE												
Pinnularia-I	P	P	P	P	P	P	P	P	P	P	P	P
Pinnularia-II	?	?	?	P	P	P	P	P	P		P	
Naviculla		P	P	P		P	P	P	P	P		P
Synedra	P	P		P	P	P	P	P	P			
Cocconeis										P	P	
Nitzschia	P	P	P	P			P	P				
Surirella										P	P	
Diatoma				P			P	P				
Fragilaria				P		P						
Frustulia												
Gyrosigma				P			P					
Asterionella							P					
DINOPHYCEAE												
Ceratium												
OTHER FORMS												
Plant spores												
Fungal filaments				P								

Tank Nos. :	27	28	29	30	31	32	33	34	36	37	38	39
MYXOPHYCEAE												
Microcystis	P	P	P	P	P	P	P	?	P	D	P	P
Anabaena	P	P		P						?	P	?
Oscillatoria	?	P							?		P	?
Nostoc	?	?			P		?		?	P	P	?
Merismopedia												
Spirulina	P	P		P		P				?	?	?
Lyngbya	P	?		P			P	P	P	P		P
Phormidium		?					?	?	?	P		P
Aphanizomenon							P		P	P		?
Coelosphaerium		P										
CHLOROPHYCEAE												
Protococcus												
Botryococcus												
Synura												
Volvox		P										
Eudorina	?	?										
Pandorina	?	P										
Pleodorina		?									P	
Uroglena												
Tribonema							P	?	?	P	?	P
Ulothrix	P	?	P	P	P	P	P	P	P	P	?	P
Microspora												
Zygnema	P	?	P	P	P	P	?	P	P	?	?	?
Oedogonium												
Spirogyra		?				P		P	?	?	P	P
Characium												
Chaetophora	P		P		P	?	?	?	P		?	P
Draparnaldia											P	
Mougeotia							?	?		P		

Tank Nos. :	27	28	29	30	31	32	33	34	36	37	38	39
Scenedesmus	P	P		P							P	
Ankistrodesmus		?		P							P	
Selenastrum		?		P							P	
Cladophora											P	
Pediastrum											?	
Unid. forms											P	
DESMIDIACEAE												
Cosmarium			P		P		P					
Closterium	P	?				P	P		?	?	?	?
Closteriopsis		?					?	P	P	?		P
Netrium							P		?			?
Mesotaenium												
Spirotaenium												
Gonatozygon												
BACILLARIOPHYCEAE												
Pinnularia-I	P	P	P	P	P	P	P	P	P	P	P	P
Pinnularia-II	P	P	P	P	P	P	P	?	P	P	P	P
Naviculla	P	P	P	P		P	P	P	P	P	P	P
Synedra	P	P	P		P	P	P	P	P	?	P	
Cocconeis												
Nitzschia	P	?	P		P		P	P	P	P	P	P
Surirella												
Diatoma												
Fragilaria							P	P	P	?		P
Frustulia												P
Gyrosigma							P					
Cymbella											P	
Asterionella	P	?										
DINOPHYCEAE												
Ceratium			P									
OTHER FORMS												
Plant spores					P			P				
Fungal filaments												

Tank Nos. :	40	41	42	43	49	51	52	53	54	55	56	58
MYXOPHYCEAE												
Microcystis	P	D	?	?	P	D	?	?	?	P	P	P
Anabaena	P				?				D			
Oscillatoria			?		D				?			?
Nostoc	P	P	D		?	P	P	?	P	P	?	?
Merismopedia												
Spirulina		D		P	D		?				P	P
Lyngbya	P		P			P	P	P	P	P	P	P
Phormidium	?		P			?	P	P	?	?	?	P
Aphanizomenon	P		P		?	?	?	?		?		P
Coelosphaerium												
CHLOROPHYCEAE												
Protococcus												
Botryococcus												
Synura												
Volvox											?	?
Eudorina												
Pandorina												
Pleodorina												
Uroglena												
Tribonema	P		?				P	?	?		?	P
Ulothrix	P		?	P		P	P	P	P	?	P	?
Microspora						P	P	P	P		P	?
Zygnema	P	P	?	P	?	?	D	D	P	?	P	
Oedogonium												
Spirogyra	P	P		P	?	P	P	P	P	?	P	
Characium						P	P	?	P		P	
Chaetophora	P	P				P	P	?	P		P	
Draparnaldia												
Mougeotia							?	P	P		P	P

Tank Nos. :	40	41	42	43	49	51	52	53	54	55	56	58
Scenedesmus	P											
Ankistrodesmus				?								
Selenastrum												
Cladophora												
Pediastrum				?								
Unid. forms												
DESMIDIACEAE												
Cosmarium	P			?		?	?	?	?	?		?
Closterium	P			?			?	?		?	?	?
Closteriopsis	?			?			?			?	P	?
Netrium	?					P	P	P	P		P	P
Mesotaenium						P	P	P	?	P	P	P
Spirotaenium						P	P	?	?		P	P
Gonatozygon							P	?	?		?	P
BACILLARIOPHYCEAE												
Pinnularia-I	P	P	P	P	P	P	P	P	P	P	P	P
Pinnularia-II	P	P	P	P	P	P	P	P	P	P	P	P
Navicula	P	P	P	P	P	P	P	P	P		P	P
Synedra	P	P	P	P	?	P	?	?	P		P	
Cocconeis												
Nitzschia	P		P	?	?	P	P	P	P	P	P	P
Surirella								P				
Diatoma												
Fragilaria	P		P			P	P	?	P	P	P	P
Frustulia			?				?		P		P	P
Gyrosigma			P						?			
Asterionella								?				
DINOPHYCEAE												
Ceratium												
OTHER FORMS												
Plant spores		P				P					?	P
Fungal filaments		?				?	?	?	?	?		

Tank Nos. :	59	60	61	63	68	69	70	71	72	75	77	78
MYXOPHYCEAE												
Microcystis	?		?	?	P	?	?	?	P	P	?	?
Anabaena	P	?	P								P	?
Oscillatoria				?							P	P
Nostoc	P	?	?	P	P	P	P	?	?	P	P	P
Merismopedia												
Spirulina	?		?									
Lyngbya	P	?		P	P				P		P	
Phormidium		P	P	P					?		P	?
Aphanizomenon			?	?	P			?			?	P
Coelosphaerium												
CHLOROPHYCEAE												
Protococcus												
Botryococcus												
Synura												
Volvox												?
Eudorina												
Pandorina												
Pleodorina												
Uroglena												
Tribonema		?		?							P	
Ulothrix	?	P	P	P	P	?		P	P	P	?	P
Microspora			?			?		?		P		
Zygnema		?	?	?	P	P		P	P	P	P	P
Oedogonium												
Spirogyra		D	D	P		P	P	?	P	P	?	?
Characium	?	P	P		P			?		P		
Chaetophora	?	P	P	P				P	?			
Draparnaldia												
Mougeotia		P	D	?	?	?		?				

Tank Nos. :	59	60	61	63	68	69	70	71	72	75	77	78
Scenedesmus												?
Ankistrodesmus												?
Selenastrum												?
Cladophora												
Pediastrum												?
Unid. forms	P	P										
DESMIDIACEAE												
Cosmarium	P	?	?									
Closterium	?	?	?	?								
Closteriopsis	?		?									
Netrium	P	P	P	?								
Mesotaenium												
Spirotaenium										P		
Gonatozygon												
BACILLARIOPHYCEAE												
Pinnularia-I	P	P	P	P	P	P	P	P	P	P	P	P
Pinnularia-II	P	P	P	P	P	P	P	P	P	P	P	P
Naviculla	P	P	P	P	P	P	P	P	P	P	P	P
Synedra	P	P	?	?	P	P	P	P	P	P	P	P
Cocconeis												
Nitzschia	P	P	D	P								
Surirella								P				
Diatoma					?	P	P	?				
Fragilaria	P	P	D	P	P	P	P	?				
Frustulia	P	P	D	P	P	P	P	P				
Cymbella				?								
Gyrosigma	P		?			P	P					
Asterionella		P										
DINOPHYCEAE												
Ceratium												
OTHER FORMS												
Plant spores	?		?								P	P
Fungal filaments	P	P	P		P	P		?	?			

TABLE 7

RESULTS OF PLANKTON ANALYSIS : ZOOPLANKTON

Tank Nos. :	1	2	3	4	5	7	8	9	10	11	12	13	15	16	17
PROTOZOA															
Difflugia-1	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Difflugia-2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Arcella					P				P						P
Centropyxis															
Pelomyxa	P	P	P	P	P									?	?
Euglypha														?	
Notholca				P											
Phacus															
Euplotes															
Uniden-)1	P		P						P		P		P	P	P
-tified 2			P		P		P	P	P	P	P		P	P	P
ciliate) 3	P	P	P	P	P		P	P	P		P		P	P	P
forms) 4-															
ROTIFERA															
Brachionus calicyflorus	P	P	P	P	P									?	P
B. diversicornis															?
B. angularis		P		P	P										
B. rubens	P			P	P										
B. forficula	P			P											
B. falcatus			P							P					
B. caudatus	P	P	P	P	P										P
B. bidentata															
Lecane															
Monostyla bulla															
Keratella	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Platias															
Epiphanes										?			?	?	
Asplanchna	P	P	P	P	P	P	P	P	P	P	P		P	P	
Rotaria														?	
Filinia	P	P	P	P	P	P	P			?		P	P	P	
Euchlanis						P	?	P	P		?		?	?	?
Testudinella	P	P	P	P	P	P	P	P	P		P	P			
Trichocerca															
Hexarthra											?				
Polyarthra											?				
Horaella	P	P	P	P	P										

Tank Nos.	1	2	3	4	5	7	8	9	10	11	12	13	15	16	17
CLADOCERA															
Moina	P	P	P	P	P		P	P	P	P	P	P	P	P	P
Bosmina	P	P	P	P	P		P	P	P	P	P	P	P	P	?
Macrothrix															
Daphnia															
Camptocercus															
Chydorus														?	
OSTRACODA															
Forms of }1	P	P	P	P	P		P		P	P	P	P	P	P	P
Cypris sp.}2	P	P	P	P	P		P					P	P	P	P
Stenocypris sp.}3	P	P	P	P	P					P	P		P	P	P
Heterocypris sp.}4	P	P		P	P		P	P	P	P	P			P	P
COPEPODA															
Mesocyclops	P	P	P	P	P		P	P	P	P	P	P	P	P	P
Spicodiaptomus	P	P	P	P	P	P	P	P	P	P	P	?	P	P	
Neodiaptomus				P		?		P	P	P	P	?	?	P	
Heliodiaptomus		P				?		P	P	P	P	?	?	P	
Nauplii	P	P		P	P	P	P	P	P	P	P	P	P	P	P
CONCHOSTRACA	P	P		P	P		P	P	P						
OTHERS															
Rabditis															
Cauborus		P													
Insect larvae															
Unid. Arthropods															

Tank Nos. :	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
PROTOZOA															
Difflugia-1	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Difflugia-2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Arcella										P	P			P	
Centropyxis															
Pelomyxa				P		P	P	P				P	P		P
Euglypha				P	P	P					?		P		
Notholca				P											P
Phacus															
Euplotes															
Uniden-}1	P	P	P	P	P	P				P	P			P	P
-tified }2	P	P	P	P	P	P					?	P		P	P
ciliate} 3				P	P	P					?	P		P	
forms} 4												P			
ROTIFERA															
Brachionus calicyflorus							P	P	P	P	P	P	P		
B. diversicornis			P							P					
B. angularis										P		P			
B. rubens							P	P		P		P	P		
B. forficula								P		P		P			
B. falcatus								P		P					
B. caudatus	P					P	P	P	P	P	P	P	P		
B. bidentata															
Lecane							P	P		P		P			
Monostyla bulla							P						P		
Keratella	P	P	P		P	P	P	P	P	P	P	P	P		P
Platias											P				
Epiphanes					P									P	
Asplanchna	P		P	P	P		P			P	?		P		P
Rotaria				P											P
Filinia	P	P	P	P	P	P	P	P	P	P	?	P	P		

Tank No.:	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Euchlanis						P				P	P				P
Testudinella				P			P		P	P	P	P	P		
Trichocerca				P				P		P	?		P		
Hexarthra				P											
Polyarthra							P								
Horaella							P	P	P	P			P	P	
CLADOCERA															
Moina		P	P	P	P	P	P		P	P	D	P		P	P
Bosmina			P	P	P		P	P	P	P	D		P		P
Macrothrix															
Daphnia											P				P
Camptocercus															
Chydorus			P	P											
OSTRACODA															
Forms of }1	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Cypris sp. }2	P		P	P			P				P			P	P
Stenocypris sp.}3	P	P	P	P						P	P		P	P	P
Heterocypris sp.}4	P	P	P	P	P	P	P	P	P	P	P	P	P		P
COPEPODA															
Mesocyclops	P	P	P	P	P	P	P	P	?	P	P	P	P	P	P
Spicodiaptomus	P			P	P	P	P		P		?		P	P	P
Neodiaptomus	P			P	?	?			P	P	P				P
Heliodiaptomus	P			P	?	?			P	P	P				?
Nauplii	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CONCHOSTRACA					P	P									P
OTHERS															
Rabditis				P									P		?
Cauborus										P		P	P		
Insect larvae															
Unid. Arthropods															

Tank Nos. :	33	34	36	37	38	39	40	41	42	43	49	51
PROTOZOA												
Difflugia-1	?	P	P	P	P	P	P	?	P	?	P	P
Difflugia-2	?	P	P	P	P	P	P	?	P	?	P	
Arcella	?	P	P	P	?	?	P		?		P	?
Pelomyxa		?	P	?	P	P	?		?		P	P
Euglypha		?			P	?	?					P
Nothoica	P			?			?					P
Phacus												
Euplotes												
Uniden-}1	P	P	P	P	P	P	P		P	P		P
-tified }2	P	P	P	P	P	P	?		?	P		P
ciliate} 3	?	P	P	P		?	?		?	P		P
forms} 4												
ROTIFERA												
Brachionus												
calicyflorus	?	D	P	P	P	P	P		?	P		P
B. diversicornis		?	P	?		P	P					?
B. angularis		P										
B. rubens		P										P
B. forficula			?			P				P	P	
B. falcatus												
B. caudatus	?	P	P	P	P	P	P			P	P	P
B. bidentata			P		P	P	P					
Lecane												P
Monostylabulla		?										?
Keratella	P	P	P	P	P	P	P	P	P	P	P	P
Platias												
Epiphanes	P	P	P	P			P		?			?
Asplanchna	P	P	P	P	P	P	P		?		?	P
Rotaria		?			P	?	?				?	
Filinia		P	?	P	P	P	P		?	?	?	P
Euchlanis	P	?	P	?			P	P	?			?
Testudinella		P		P	P	?	?		P		?	?
Trichocerca						P						P
Hexarthra												P
Horaella												P

Tank No.:	33	34	36	37	38	39	40	41	42	43	49	51
CLADOCERA												
Moina		P	?	P	P	P	P		?	P	D	?
Bosmina		?	?	P	P	P	P			P	D	
Macrothrix												
Daphnia					P						D	
Camptocercus												
Chydorus		P		?			P	D				
OSTRACODA												
Forms of }1	P	P	P	P	P	P	P	P	P	P	D	P
Cypris sp. }2	P	P	P	P	P	P	P	P	P	P	D	P
Stenocypris sp.}3	P	P	P	P	P	P	P	P	P	P	D	P
Heterocypris sp.}4	P	P	P	P	P	P	P	P	P	P		P
COPEPODA												
Mesocyclops	P	P	D	P	P	D	P	?	P	P	D	P
Spicodiaptomus	?	P	?	?	?	P	P				D	?
Neodiaptomus		?			?	?	?				D	
Heliodiaptomus		?				?	?				P	
Nauplii	P	P	D	P	P	P	P	P	P	P	D	P
CONCHOSTRACA												P
OTHERS												
Rabditis					P							
Cauborus					P							
Insect larvae												
Unid. Arthropods						P						

Tank Nos. :	52	53	54	55	56	58	59	60	61	63
PROTOZOA										
Difflugia-1	P	P	P	?	P	P	P	P	P	P
Difflugia-2	P	P	P	?	P	P	P	P	P	P
Arcella	?	?	?	?	?	?	?	?	?	
Centropyxis										
Pelomyxa	?		?		?			?	?	P
Euglypha		?					?	?	?	P
Notholca	?									
Uniden-}1	P	P	P		P	P	?	P	P	P
-tified }2	P	P			?	P	?	?	?	P
ciliate} 3	P	P			?	P	?	?	?	
forms} 4	?									
ROTIFERA										
Brachionus calicyflorus	P	?	P	P	P	?		?		P
B. diversicornis	?	?	?							
B. angularis		?	?							
B. rubens	P									
B. forficula					P					P
B. falcatus										
B. caudatus	P	P	P	P	?	?				P
B. bidentata		P								
Lecane	?	P	?	?						
Monostyla bulla		P	?							
Keratella	P	P	P		P	P	P	P	P	P
Platias	?									
Epiphanes	?	?	?				?	P	?	
Asplanchna	P	?	?		?		P	P	P	?
Rotaria										?
Filinia	P	P	?		P	P	P	?	?	
Euchlanis	?	?	?		?		P	?	?	
Testudinella	?						?	P	?	?
Trichocerca		?								
Hexarthra										
Polyarthra										
Horaella	?	?								

Tank No.:	52	53	54	55	56	58	59	60	61	63
CLADOCERA										
Moina	P	P	P		P	P	?	?	P	D
Bosmina	P	?		P	P				?	D
Macrothrix					?	P				
Daphnia										D
Camptocercus					P	P				
Chydorus		P	P	P	P	P		P	P	
OSTRACODA										
Forms of }1	P	P	P		P	P	P	P	P	D
Cypris sp. }2	P	P	P	P	P	P	P	P	P	D
Stenocypris sp.}3	P	P	P	P	P	P	P	P	P	D
Heterocypris sp.}4	P	P	P	P	P	P	P	P	P	
COPEPODA										
Mesocyclops	P		P		P	P	P	P	P	D
Spicodiaptomus	?	?	?		?	?		P	P	D
Neodiaptomus	?					?		?	?	D
Heliodiaptomus	?									D
Nauplii	P	P	P	?	P	P	P	P	P	D
CONCHOSTRACA	P	P	P	?	P	P	P	P	P	
OTHERS										
Rabditis										
Cauborus										
Insect larvae				P						
Unid. Arthropods										

Tank Nos. :	68	69	70	71	72	75	77	78	79	80
PROTOZOA										
Difflugia-1	P	P	P	P	P	P	P	P	P	P
Difflugia-2	P	P	P	P	P	P	P	P	P	P
Arcella	P					P	?	P	?	P
Pelomyxa					?		?	P		
Euglypha					P					
Uniden-}1	P	?		?	?	P	P	P	P	P
-tified }2	P	?	?	?	?	P	P	P	P	P
ciliate} }3	P	?		?	?	P	P	P	P	
forms} }4										
ROTIFERA										
Brachionus calicyflorus				?	?	P	P	P	?	
B. diversicornis										
B. angularis										
B. rubens										
B. forficula	P					P	?		?	
B. falcatus	P			?		P			P	
B. caudatus	P		P	P		P	P	P	?	
B. bidentata										
Lecane										
Monostyla bulla										
Keratella	P	P	P	P	P	P	P	P	P	
Platias										
Epiphanes		P	P	?	?		P	?	?	
Asplanchna	P			?		P			?	
Rotaria	P	P		p				?		
Filinia	P	P	P	P	P	P	P	P	P	P
Euchlanis					?		P	?		
Testudinella		?				P	?	P	?	
Trichocerca										
Hexarthra										
Polyarthra										
Horaella						P				

Tank No.:	68	69	70	71	72	75	77	78	79	80
CLADOCERA										
Moina	P	P	P	P	P	P	P	P	P	P
Bosmina							P	P	P	
Macrothrix										
Daphnia				P			P	P		D
Camptocercus										
Chydorus		P	P							
OSTRACODA										
Forms of }1	P	P	P	P	P	P	P	P	P	P
Cyris sp. }2	P	P	P	P	P	P	P	P	P	P
Stenocypris sp.}3	P	P	P	P	P	P	P	P	P	P
Heterocypris sp.}4	P	P	P	P	P	P	P	P	P	P
COPEPODA										
Mesocyclops	P	P	P	P	P	P	P	P	P	P
Spicodiaptomus	P	P		P	P		?	P	P	P
Neodiaptomus	?	?		?	?		?	?	P	?
Heliodiaptomus	?	?		?	?		?	?	P	?
Nauplii	P	P	P	P	P	P	P	P	P	P
CONCHOSTRACA										
OTHERS										
Rabditis										
Cauborus	P	P	P	?						
Insect larvae										
Unid. Arthropods										

Tank Nos. :	85	86	87	88	89	90	94	95	96	97
PROTOZOA										
Difflugia-1	P	P	?	P	P	P	P	P	P	P
Difflugia-2	P	P	?	P	P	P	?	P	P	P
Arcella	P	?		P	P	P		P	P	?
Centropyxis										
Pelomyxa	?			P	?	?				
Euglypha	P			P					?	
Notholca										
Phacus										?
Euplotes										
Uniden-}1	?	?		?	?	?		P	?	P
-tified }2	?	?		?	?	?		P	?	P
ciliate} 3	?	?		?	?	?		P	?	P
forms} 4										
ROTIFERA										
Brachionus										
caliciflorus	P	P		P	P	P			P	
B. diversicornis	P	P		?	?					
B. angularis										
B. rubens										
B. forficula									D	
B. falcatus										
B. caudatus	P	P		P	P	P			P	
B. bidentata			P							
Lecane										
Monostylabulla										
Keratella	P	P	?	P	P	P		P	P	
Platias										
Epiphanes	P	P		P		P				
Asplanchna	P			?	?	?		P	?	
Rotaria					?			P	?	
Filinia	P	P		?		?			?	
Euchlanis	?	?		P	P	?				
Testudinella	P				?	P				
Trichocerca										
Hexarthra										
Polyarthra										
Horaella										

Tank No.	85	86	87	88	89	90	94	95	96	97
CLADOCERA										
Moina	P	P	P	?	P	P				
Bosmina	P	?	?			P				
Macrothrix										
Daphnia		P	?							
Camptocercus										
Chydorus	P					P			P	
OSTRACODA										
Forms of }1	P	P	P	P	P	P		P	P	
Cypris sp. }2	P	P	P	P	P	P		P	P	
Stenocypris sp.}3	P	P	P	P	P	P		P	P	
Heterocypris sp.}4	P	P	P	P	P	P		P	P	
COPEPODA										
Mesocyclops	P	P	P	P	P	P		P	P	
Spicodiaptomus							P	?		
Neodiaptomus							?	?		
Heliodiaptomus							?	?		
Nauplii	P	P	P	P	P	P		P	P	
CONCHOSTRACA										
OTHERS										
Rabditis							?			?
Cauborus								P		
Insect larvae										
Unid. Arthropods										

APPENDIX

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