POSTER PAPERS

VIII IWRA WORLD CONGRESS
ON WATER RESOURCES

SATISFYING FUTURE NATIONAL AND GLOBAL WATER DEMANDS

Cairo, November 21 - 25, 1994

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INDEX OF POSTER PAPERS

A STANDARD FOG COLLECTOR FOR USE IN MEASURING HYDROLOGICAL INPUTS IN MOUNTAINOUS AREAS

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ABSTRACT

The collection of fog droplets by vegetation is an important wet deposition process. It can, in fact, dominate the chemical and hydrological input to certain high elevation watersheds. However, measurements of fog deposition are rarely made and, where they do exist, comparisons of deposition rates in different locations have been hampered by the use of innumerable types of collection devices. A simple, inexpensive, 1 m^2, fog collector that can produce measurements of the deposition of fog water to vertical surfaces is described here. The collector has been used successfully in five countries to investigate the variation of fog deposition in complex terrain and to estimate the deposition to trees and to much larger fog collectors. It is recommended that it be widely employed as a standard to quantify the importance of fog deposition to forested high elevation areas and to measure the potential collection rates in denuded or desert mountain ranges.

La collecte des gouttelettes de brouillard par la végétation est un important processus de dépôt humide. De fait, elle peut constituer l'apport chimique et hydrologique le plus important dans certains bassins situés à haute altitude. Toutefois, la mesure des dépôts de brouillard est rarement effectuée et, si elle existe, la comparaison des taux de dépôt à divers endroits est entravée par l'utilisation d'innombrables types de dispositifs de collecte. On décrit ici un collecteur de brouillard de 1 m^2, simple et peu coûteux, qui peut mesurer le dépôt d'eau de brouillard aux surfaces verticales. On s'est servi avec succès du collecteur dans cinq pays pour étudier la variation du dépôt de brouillard dans un terrain complexe et estimer le dépôt aux arbres et à des collecteurs de brouillard bien plus grands. On conseille d'étendre l'usage de ce collecteur, comme élément standard, pour quantifier de dépôt de brouillard dans des zones boisées de forte altitude et mesurer le taux éventuel de collecte dans les chaînes montagneuses dépouillées ou désertiques.

1. INTRODUCTION

The only source of new water for watersheds is considered to be precipitation. Measurements of drizzle, rainfall, and snowfall, in several locations, are integrated to estimate the annual water input. This produces acceptable results in low elevation watersheds, or in barren higher elevation sites, but in forested high elevation areas, which experience frequent episodes of fog as a result of the advection of clouds over the surface of the mountain, the consideration of precipitation alone may seriously underestimate the water input to the watershed. A number of summaries of fog collection experiments have been made (e.g. Kerfoot, 1968; Stadtmüller, 1987; Schemenauer and Cereceda, 1991; Vong et al., 1991) that clearly show the importance of fog as a wet deposition source. Even in extremely arid environments, such as the mountains along the north coast of Chile, fog can be present on more than half of the days of the year (Cereceda and Schemenauer, 1991).

A very large number of measurements of the collection of fog by trees and various types of collectors have been made over the last century, but it is almost impossible to quantitatively compare the collection rates. There are two main reasons for this. The first is that in many experiments the investigators neglected to determine the amount of precipitation that was also entering the collector. This can be very significant in windy high elevation sites and has been discussed, for example, by Fourcade (1942) in his critique of fog collection experiments near the turn of the century in South Africa. The second major reason for the lack of quantitative comparisons is the wide range of artificial collection devices that have been used. Schemenauer et al. (1988) illustrate, for example, some of the devices that were used in Chile over a 30 year period. Many other devices were used at earlier times in other countries, e.g. Marloth (1905) in South Africa used reed bundles on top of a standard rain gauge. These, and other examples, confirmed what had been observed in forests in many experiments, i.e. a vertical collecting surface (a tree) can produce additional water on the forest floor on both days with rain and fog, and on days with fog alone. Unfortunately, for the reasons stated above, it is impossible to make quantitative use of the data generated in most of these projects.

During the last eight years projects have been undertaken for the extraction of large quantities of water from high elevation fogs, for domestic and agricultural purposes, in developing countries, e.g. Cereceda et al., (1992a,b). These projects have given rise to a requirement for an inexpensive fog collector that is robust enough to survive extended exposure in harsh environments. The construction and use of this collector are described below.

2. THE PROPOSED STANDARD FOG COLLECTOR

2.1 The Construction

The construction and installation of the proposed standard fog collector (SFC) are described in detail in Schemenauer and Cereceda (1994a). It consists of a double layer of polypropylene mesh mounted on a rigid frame. The inside dimensions of the mesh are 1.00 m by 1.00 m and the frame is mounted with its base 2 m above ground. A plastic or metal trough collects the water dripping off the mesh and an outlet tube takes the water to a storage vessel or flow measuring device. Figure 1 shows a SFC on a mountain called Cerro Orara just north of Lima, Peru. The results of an extensive field investigation at this site are given in Cereceda et al. (1994). The dimensions of the SFC are given in Figure 2.

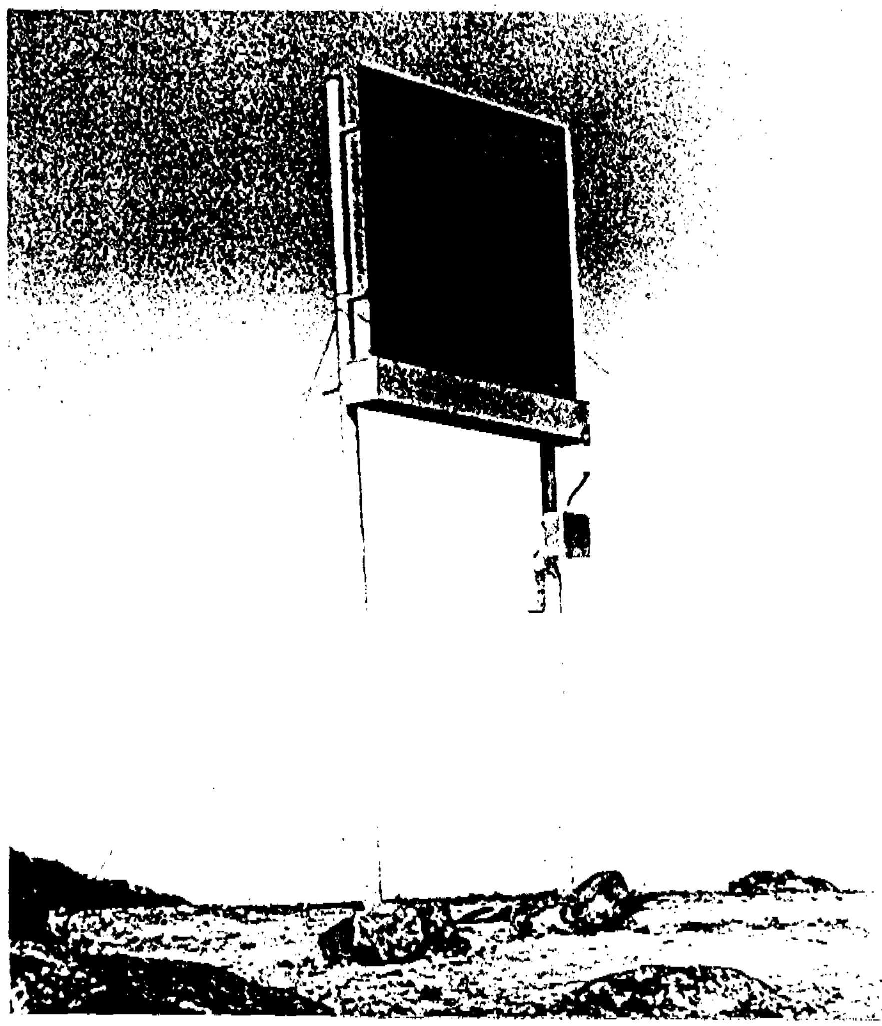

Figure 1. A standard fog collector on Cerro Orara, Peru. The mountain (elev. 430 m) is 50 km north of Lima.

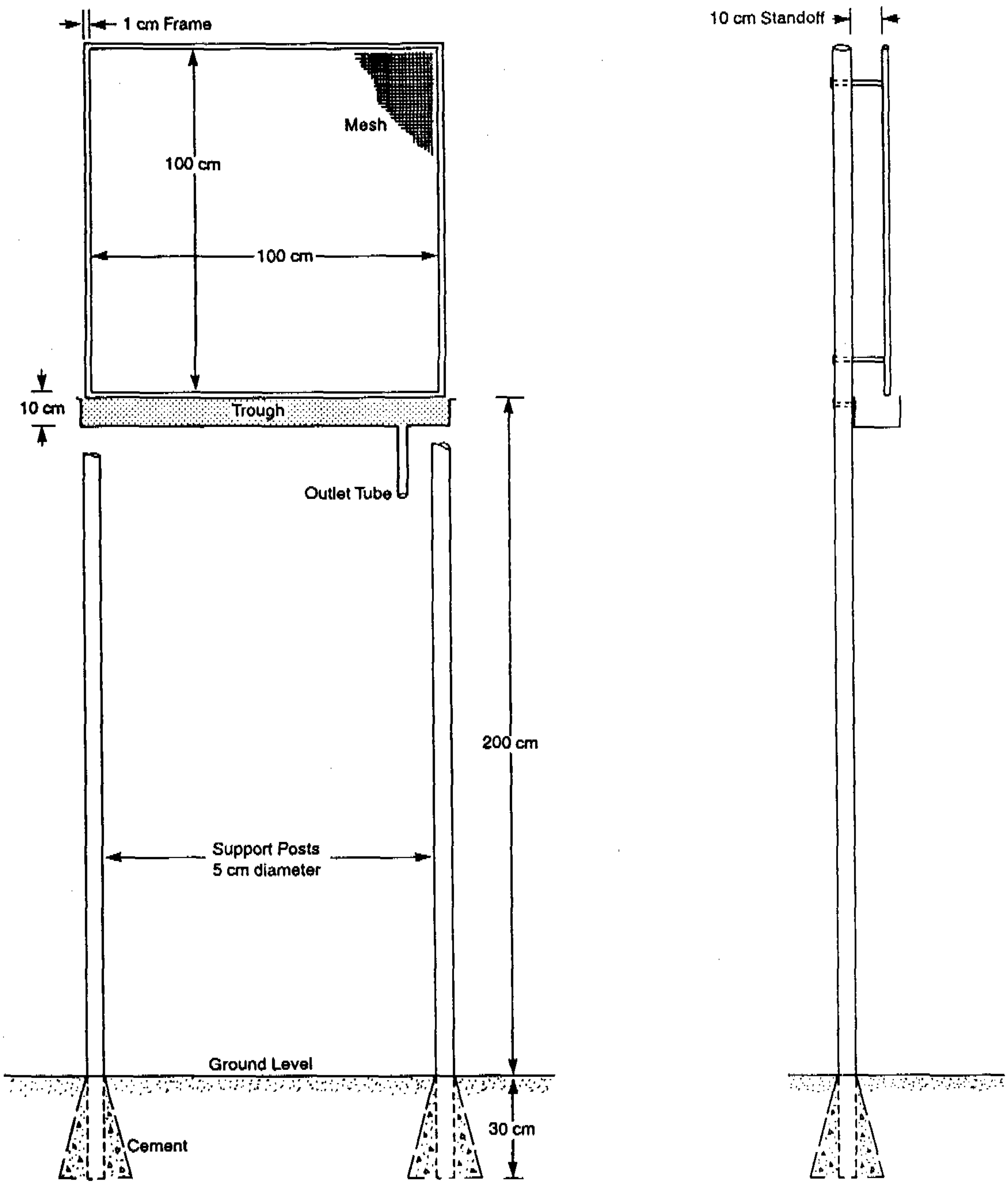

Figure 2. Dimensions of the standard fog collector.

The use of a fog collector that is a flat surface lowers the cost, reduces the complexity of construction, and aids greatly in the interpretation of the results. The SFC is mounted facing the predominant wind direction during fog events. If this direction is unknown, or if the contributions of fog from different directions must be known, one can use an omnidirectional SFC. It is an innovative adaptation of a single post fog collector, which employs bearings and a wind vane, to keep the panel of the SFC normal to the wind. By the use of eight receiving containers, the wind direction producing the maximum fog deposition can be determined. It has been seen that functional omnidirectional collectors can be constructed in local machine shops in developing countries and that they are valuable in locations with highly variable wind directions. The quantifying of fog deposition by octants is information that cannot be obtained by a fixed SFC or a cylindrical collector. Cereceda et al. (1994) discuss results from an omnidirectional fog collector.

The SFC is not suitable for the collection of fog water for chemical analysis, since it is not normally cleaned other than to ensure that the collected water flows unimpeded to the flow measuring device. Another type of specialized fog collector can, however, be used to collect water for subsequent analysis (Schemenauer and Cereceda, 1992a,b).

2.2 The Mesh

The mesh should be of the same material in all of the standard fog collectors, to enable direct comparisons to be made between sites and subsites and between locations in different countries. The mesh is placed on the collector frame in a double layer and thus slightly more than 2 m^2 of mesh is required for each collector.

The 35% shade coeffficient, polypropylene, u.v. protected, black, mesh can be ordered from Coresa in Chile. Mesh with a horizontal line spacing of 1.3 cm should be specified as other line spacing is available. Cost at this time is <$0.25 US m^{-2}. Expected lifetime in field use appears to be about ten years. The mesh is available in 8 m wide rolls in essentially any length. A folded 8 m wide mesh will make a double layered 4 m high fog collector.

1. Coresa
   San Nicolás 630
   Casilla 14072
   Santiago 13, Chile
   Tel. (56-2)5521344 FAX (56-2)5521638

An essentially identical polypropylene mesh can be ordered from Marienberg S.A. in Chile. The same specifications should be given.

2. Marienberg S.A.
   Exposición 202
   Santiago, Chile
   Tel. (56-2)6898981 FAX (56-2)6892888

Another source of u.v. protected mesh is Tildenet Ltd. in the United Kingdom. The SD 40% standard, black, polyethylene mesh is very similar to the polypropylene meshes described above. It is available in 4 m wide rolls in lengths of 100 m. Expected lifetime, quoted by the manufacturer, is three to five years. Cost is four to five times higher than for the Chilean meshes. The company is represented by a worldwide network of distributors.

3. Tildenet Ltd.
Longbrook House
Ashton Vale Road
Bristol BS3 2HA
England
Tel. (44-272)669684 Fax (44-272)231251

2.3 Drizzle and Rain

If an event occurs with drizzle or rain, the mesh will collect almost all of the precipitation that would have fallen into the rain shadow area behind the collector (Schemenauer and Cereceda, 1992c). The collected volume of water will contain both fog and precipitation in proportions that can be established, if there are supporting wind speed and conventional raingauge data. In some locations, such as the coasts of Peru and northern Chile, the amount of precipitation is negligible (< 10 mm per year) and the water collected on the vertical mesh can be assumed to be from fog with a minimal error. In other locations, the water will have to be assumed to be from both fog and precipitation unless the inputs can be decoupled using supporting data. This is not necessarily a detriment since it will still represent what both trees and large collectors will receive. The collection must, however, not be stated as being from fog alone in these cases.

2.4 Units of Measurement

The output of the standard fog collector is liters of water. Since the surface area is 1 m^2, this gives a collection in L m^{-2}. Normally one is interested in daily values and, therefore, units of L m^{-2} d^{-1} are recommended. Other time periods can also be specified while still preserving the core information of the number of liters of water that were collected. This has proven to be a useful unit for the calculation of both deposition values to forests and for calculating the output of large collectors. One L m^{-2} is equivalent to a depth of water of 1 mm over the 1 m^2 of the collector.

2.5 Data Collection

When the standard fog collector is equipped solely with a container to store the collected water, only the most basic of information is obtained and the time resolution will depend on the frequency with which the observer can visit the site. This is normally once each day, or once each week in remote areas. Thus one might know the number of liters of water per m^2 collected each week but not, for example, the difference between daytime and nighttime collection.

In order to obtain more detailed information to better understand the fog water production characteristics at the sites, a sophisticated but comparatively inexpensive (< $1000 US) package was assembled to collect and record the field data. It consists of wind speed and direction sensors, a tipping bucket for the fog collector, a tipping bucket raingauge, and a data logger with three or four channels. The instrumentation is described in Schemenauer and Cereceda (1994a).

3. THE USE OF THE STANDARD FOG COLLECTOR

The primary use to date of the SFC has been to examine the different fog collection rates on a topographic feature such as a ridgeline. The applications are in desert reforestation and in the siting of large fog collectors. The collection rates depend on the local fog frequency, fog liquid water content and wind speed. The liquid water content may in turn be related to droplet size, which will affect collection efficiency. Anemometers have been mounted on the SFCs, and the measurements made 50 cm to one side. All data are recorded on data loggers. This enables one, for example, to relate lower fog collection rates at a second subsite to lower wind speeds. One can sort out the relative importance of fog frequency, fog liquid water content and wind speed at the different sites. In a similar manner, the variation in collection rate with height above ground has been investigated in several countries using a series of SFCs on a 10 m tower.

Schemenauer and Cereceda (1992c) have looked at the mechanisms by which trees collect fog and precipitation. They also reviewed the rates at which trees collect fog and drizzle as measured by a number of authors. The rates, normalized to a vertical cross section, were quite variable, 6 to 70 L m^{-2} d^{-1}, depending on the conditions and the duration of the experiment. Where there are comparable measurements with a SFC, the collection rates are similar. For example, at Masroob, Oman, an olive tree (Olea europaea) on a hilltop at 920 m collected an average of 70 L m^{-2} d^{-1} over 79 days in 1989 (Barros and Whitcombe, 1989) and a SFC averaged 86 L m^{-2} d^{-1}. This is excellent agreement considering that there is some uncertainty in knowing the vertical cross section of the tree, some water may have evaporated from the tree during the rare dry periods, and since some water dripping from the tree is known to have escaped the collection container. Work with other species of isolated trees has also suggested that the SFC can provide useful estimates of the collection rates of wind driven fog and precipitation.

4. HYDROLOGIC APPLICATIONS

The flow of fog over a hillside can be compared to the flow of water in an underground aquifer. The water is available for use. It simply needs to accessed. A well can be used to take water from the ground. A vertical collector is used to obtain the fog water. The vertical collector can be a tree or it can be a man-made collector. In either case, the horizontally moving droplets in the fog are caught when they impact on the leaves or fibers of the collector. To assess the hydrologic importance of fog in an upland area, one needs to know the horizontal flux of fog water in the air close to the ground. This can be obtained by deploying standard fog collectors in the region of interest and integrating the results from the collectors. Certain topographic features will have higher collection rates and these should be carefully investigated. Guidelines for siting fog collectors have been discussed elsewhere (Cereceda-Troncoso et al., 1988; Schemenauer and Cereceda, 1994b).

The horizontal flux of fog water is important hydrologically because some of the water will be deposited on the soil by turbulent diffusion. However, the horizontal flux becomes of much greater hydrologic importance when it is intercepted by tall vegetation such as trees. The trees convert the horizontal flux of tiny fog droplets to a vertical flux of much larger drops.

The flux of fog water as measured with a SFC is correlated with the collection rates of trees and it can be used to infer the collection by a forest or by isolated trees and shrubs. One portion of the water will remain in the trees (interception) and will ultimately evaporate; the remaining fraction will drip from the trees onto the ground. Some of this water will runoff on the surface, some will percolate into the ground and some will evaporate. Normally evaporation is small in foggy environments because the humidity is near 100% much of the time. Some measurements of the amounts of water dripping from trees have been summarized (Schemenauer and Cereceda, 1992c) and it was concluded that trees in foggy environments collect more water than they need to sustain themselves. The collection rates averaged from 0.5 to 5 cm day^{-1} during the fog season. The water that was surplus to the trees' needs contributed to the storage in the aquifers.

The amount of water that this mechanism (fog collection by trees) can contribute to the water resources in a region will depend on many factors but it can be of the order of 100 mm in a year in arid or semi-arid regions and may well be much higher in tropical cloud forests. Routine measurements with SFCs can allow for estimates of the collection by forests in forested areas as well as providing the core data needed to assess the viability of natural or man-made collectors in barren areas.

5. DISCUSSION

The construction and use of a simple, inexpensive fog collector has been described and its use as a standard (SFC) is proposed. Its applications are many, since the deposition of fog water to vegetation at higher elevations has been largely neglected in hydrological studies, and since the need for potable water in developing countries is leading to the consideration of fog as a new water resource. A fixed fog collector mounted in a vertical frame is the most practical for simplicity of construction and maintenance, and will result in the lowest costs. The large variability in fog deposition rates with altitude and with topography leads to the need for the deployment of SFCs in large numbers. For this purpose, the collectors can be used with nothing more than a container to store the accumulated amount of water. In more elaborate installations, a data logger can record the water output continuously as well as wind speed and direction information. A standard fog collector site that includes wind speed data and conventional rain gauge data can also provide information on the relative proportions of fog and precipitation being collected.

It is recommended that serious consideration be given to the widespread installation of standard fog collectors in mountainous areas, to assess the contribution of fog water to the sustainability of these sensitive regions. The contribution fog makes to the wet deposition of pollutants to mountain forests is well accepted. The same attention should be given to monitoring the real and the potential water inputs from fog to high elevation areas.

6. ACKNOWLEDGEMENTS

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SUBSURFACE DRIP IRRIGATION OF SUGAR CANE IN EGYPT

By

Dr. Dia El Quosy*

Egypt is approaching an era of sever deficit in water budget. The supply of water to the country is fixed to its share of the Niles water ; while demand is continuously increasing due to the rapid increase in population growth.

The production of sugar in Egypt is almost one million ton/year obtained from an area of about 300,000 Feddans (120,000 hectares) cultivated with cane. This area (about 2% of the cropped area) consumes an average of 5.5 billion m^3 of water every year or approximately 10% of the total water budget of the country. In view of the high initial, operation and maintenance cost of drip irrigation systems, sugare cane is normally irrigated by surface methods. However, with regard to the expected gap between supply and demand in the near future, water should be taken into consideration as an economic commodity.

An experiment is being carried out in Kom-Ombo Area ; 45 km north of the boarder city of Aswan ; on the comparison between the traditional methods of irrigating sugar cane and other fields irrigated with modified surface (pipeline), overhead sprinkler and subsurface drip irrigation systems.

The merits and limitations of each of these methods will be discussed from the technical, economic and social points of view.

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SUBSURFACE IRRIGATION OF SUGAR CANE IN EGYPT

Dr. Dia El Din El Quosy*

1- INTRODUCTION

Cultivation of Sugar Cane in Egypt goes back to the seventh century. It might had been transfered from Upper Nile countries like Kenya, Tanganika, Zenzbar and Uganda where rainfall is plentiful and swampy areas are widespread.

At the present time, Egypt cultivates an area of about 300,000 feddans (1 feddan = 0.42 hectare) with sugar cane every year. This area is concentrated in the upper and middle parts of the country where a number of sugar factories are scattered along the Nile Valley (see fig.1). Minor areas in the Nile Delta and Fayoum are cultivated with sugar cane but for other purposes than the production of sugar.

The per capita consumption of sugar in Egypt according to the latest statistics is a little more than 25 kg/capita/year. This is probably one of the highest in the world. It is almost five times the per capita consumption in a country like Japan.

Egypt produces almost one million tonnes of sugar every year, sugar imports are estimated at half a million tonnes.

The reason for sugar importation is two fold: first, the capacity of the existing factories is not sufficient for the handling of the extra amount ; second, sugar cane is a very high water consuming crop ; the water which irrigates one feddan of sugar cane is adequate, on average, for the irrigation three feddans cultivated with other crops.

High water consumption of sugar cane in Egypt is attributed to: i) high evaporative demand in the areas where the crop is grown, ii) it is a perennial crop which is harvested once every twelve month ; and iii) storage of moisture in the canopy is an important characteristic of the crop.

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As water resources in Egypt are becoming more and more scarce due to the fast growing population and the increasing demand for domestic and industrial water supply, strict measures are currently taken to economise in agricultural water use. One of these measures is to replace sugar cane cultivation with sugar beet which is : i) a winter crop, ii) it is grown in the northern part of the Delta where climate is much cooler ; and iii) it consumes one sixth the irrigation water of sugar cane.

However, growers and producers of sugar cane defend their industry on the basis that sugar is not the only product they are after, other bi-products of sugar industry are: i) bagasse which is used as livestock feed, for the production timber, paper and synthetic fibers and as a fuel,ii) molases, iii) alcohol, iv) perfumes, v) yeasts...... and many others.

This type of controversy makes it extremely difficult for any decision maker to take action on whether to continue with the cultivation of sugar cane or to convert to sugar beet and when? Obviously, water is the decisive factor in answering this equation.

From this point, the idea of employing modern technologies in reducing water losses in the process of sugar cane irrigation was brought about. Clearly the idea of irrigating this crop with modern irrigation systems is not brand new. Several attempts were made before and fairly good results were reached. What is new in the present research is the introduction of subsurface drip irrigation as one of the most promising alternatives because it brings losses to almost nil in one hand and it protects the enviroment from the pollution caused by exposing water to the atmosphere on the other. Third, it saves also in the consumption of fertilizers by giving the appropriate dose at the appropriate place (i.e. the root zone). Again the introduction of improved surface irrigation could provide a less expensive alternative with respect to initial and running costs and in the mean time protects the enviroment as well from pollution.

2- OBJECTIVES

The objectives of this research are three fold:

a- to determine the actual water requirements of sugar cane in the locality where the experiment is conducted (Kom-Ombo)

b- to compare between the on farm irrigation water losses when sugar cane is irrigated by conventional surface, improved surface, overhead sprinkler and subsurface drip methods.

c- to test the feasibility of using modern systems in the irrigation of sugar cane. The enviromental impact of using such systems will be accounted for as well.

3- DURATION

The duration of this research is expected to be for three successive years. Installation of the irrigation systems started late in 1992 and early in 1993. The plant crop under improved surface irrigation was planted in the autumn on October 24, 1992. The plant crop under sprinkler and drip irrigation was planted in the spring on April 20, 1993. Harvesting of the first took place on February 1st 1994 (age of crop 371 days) while harvesting of the others was carried out on March 1st, 1994 (age of the crop 310 days).

4- THE SITE

The site in which the experiment is conducted lies in the Mechanised Farm, Wadi Khrait, Kom-Ombo. The farm is located at about 25 km to the east of the city of Kom-Ombo which, in turn, lies at about 45 km to the south of Aswan (see fig.2).

The study area lies on latitude 24° 29 Longitude 32° 56, altitude is almost 155 m above mean sea level, maximum temperature ranges between 23° & 41° in January and June respectively and the minimum temperature ranges between 5.7 & 21.7 in February and June respectively.

The land in which the experiment is carried out is owned by the Sugar and Bi-Products Company which also owns a sugar factory in Kom-Ombo in addition to another nine factories in the Upper and Middle Egypt as shown earlier in Fig.1. Wadi Kom-Ombo is known to be one of the largest centers of sugar cane production in Egypt since the beginning of this century. It's area was extended since the 1960's by adding new reclamation lands which came up to about 55,000 feddans.

The Mechanised Farm is part of one of these reclamation projects, (Wadi Khrait Project).

5- THE EXPERIMENT

Fig. 3 shows the layout of the experimental area. The total area is divided into three treatments: sprinkler, drip and improved surface irrigation. Each treatment is further sub-divided into two divisions in the case of sprinkler and drip: one irrigated every day ; the other irrigated once every three days. Each of these sub- divisions is divided into four replicates of 320 m^2 area each.

In both sprinkler and drip irrigation the soil was kept at a moisture content equivalent to field capacity in one unit, field capacity minus 20% in another unit and field capacity plus 20% in the third.

Solid set-over head sprinkler system is used in which the height of risers is adjusted according to plant height. Subsurface drip lateral lines are installed at 0.75 m apart with the spacing between emitters 0.5 m.

The improved surface irrigation is represented by three strips: the first includes ten furrows, the second twenty furrows and the third contains thirty furrows all irrigated by means of pvc pipeline slotted to allow water to flow directly to the furrows.

The area occupied by modern irrigation systems is composed of sandy clay loam which has a moisture content at field capacity ranging between 21.3 & 32.9%. The area occupied by improved surface irrigation is composed of clay to clayey loam with the moisture content at field capacity in the margin of 28.5 to 45% by weight. The pH values range between 7.6-7.9 in the first and 7.2-7.6 in the latter. Calcium carbonate content ranges between 12.40 - 16.63 in the first and 14.66 - 18.61 in the latter. Total Nitrogen and available Phosphorous contents are extremely low in both cases. The levels of Potassium, Iron, Manganese and Copper are reasonable while Zink content is very low.

6- RESULTS

Table (1) gives the results of the first year of the experiment from which the following conclusions can be drawn:

* The yield in all cases, expect for the plots in which the soil moisture content was kept below the field capacity level, was around or above the overall average yield in the area and in the country which is close to 55 tonnes/feddan.

* Yields in the case of sprinkler irrigation are fairly similar to those of the drip irrigation system. However, the quantity of irrigation water in both cases is substantially different. The variation ranges between 25-30% more in sprinkler than in drip.

  The reason for this is that losses by evaporation from water droplets in the air and evaporation of water intercepted by plant leaves contribute to such variation ; this especially as temperatures at peak demand in the area are very high. This brings the water utilisation efficiency for harvested yield from an average of 5.5 kg/m^3 with sprinkler to about 7.5 kg/m^3 with drip.

* It should be noted that the comparison between modern and surface irrigation systems from this experiment is not relevant, simply because of the difference in age (310 days versus 371 days respectively) however, the second ratoom will give equal ages in both treatments.

* The water consumption of improved surface irrigation plots is typical to that suggested by both the Soil & Water Research Institute of the Agricultural Research Center and the Water Distribution & Irrigation Systems Research Institute of the Water Research center. The yield, in the mean time, is around the average yield which gives an idea that this system could prove to be the best because of the cheap installation cost and the advantage of depending on gravity and not energy in day to day operation.

* It should be noted that the water consumption of conventional surface irrigation (10930 m^3/f) is estimated by adding 20% on farm losses to the actual consumptive use (9110 m^3/f).

* The results of this experiment led to the conclusion to cancel the replicates of irrigation to a moisture content less than field capacity and increase the number of replicates irrigated to field capacity and more accordingly.

7- CONCLUSIONS

Definite conclusions can not be drawn at this stage, however, the potential of suing improved surface irrigation and/or drip irrigation systems in the sugar can field appeares to be promising. With less water duties, adding fertilisers to irrigation water and better water management crop yields are increasing. Irrigation of sugar cane with sprinkler systems is not practical because of the evaporation of water droplets in the air as well as the evaporation of the water intercepted by plant leaves.

Table (1): Results of the First Year of the Experiment

System	Treatment	Replicate	No of Irrigation Gifts	Irrigation Water Quantity m³/f	Yield T/F	Water Utilisation Efficiency for Harvested Yield (kg/m3)
Sprinkler	Every day	(FC)-	214	7235	47.2	6.5
		(FC)	214	9647	58.3	6.0
		(FC)+	214	12059	61.8	5.1
	Every three days	(FC)-	91	6773	44.8	6.6
		(FC)	91	9031	53.6	5.9
		(FC)+	91	11288	51.0	4.5
Drip	Every day	(FC)-	213	5076	38.6	7.6
		(FC)	213	6768	54.1	8.0
		(FC)+	213	8460	55.7	6.6
	Every three days	(FC)-	92	5049	38.2	7.6
		(FC)	92	6731	54.3	8.1
		(FC)+	92	8414	60.4	7.2
Improved Surface	10 Furrow strip		19	9078	50.1	5.5
	20 Furrow strip		19	9113	52.9	5.8
	30 Furrow strip		19	9061	50.6	5.6
Surface				10930* (Estimated)	55.0 (Average)	5.8

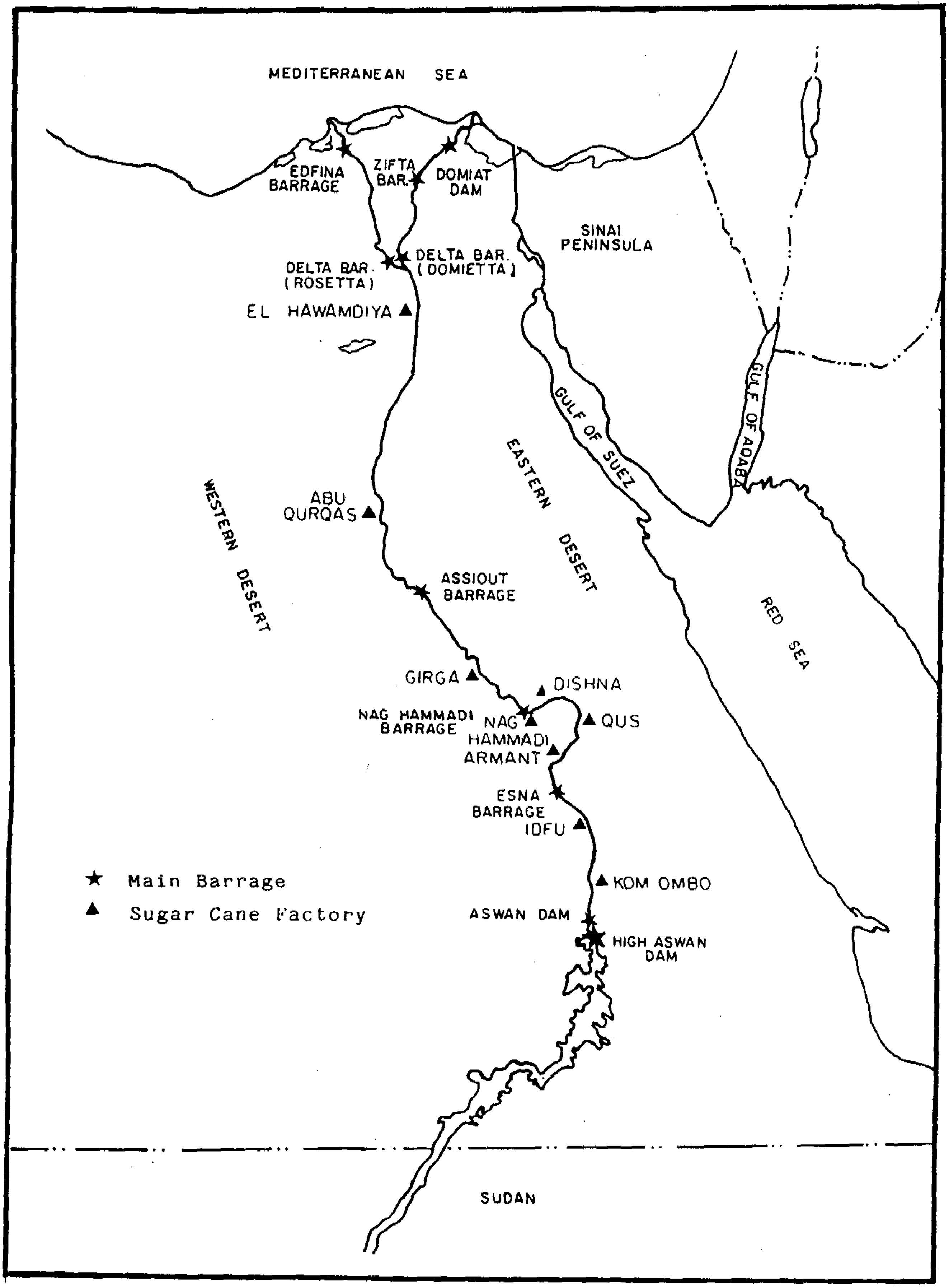

Fig. (1) Sugar Factories in Egypt

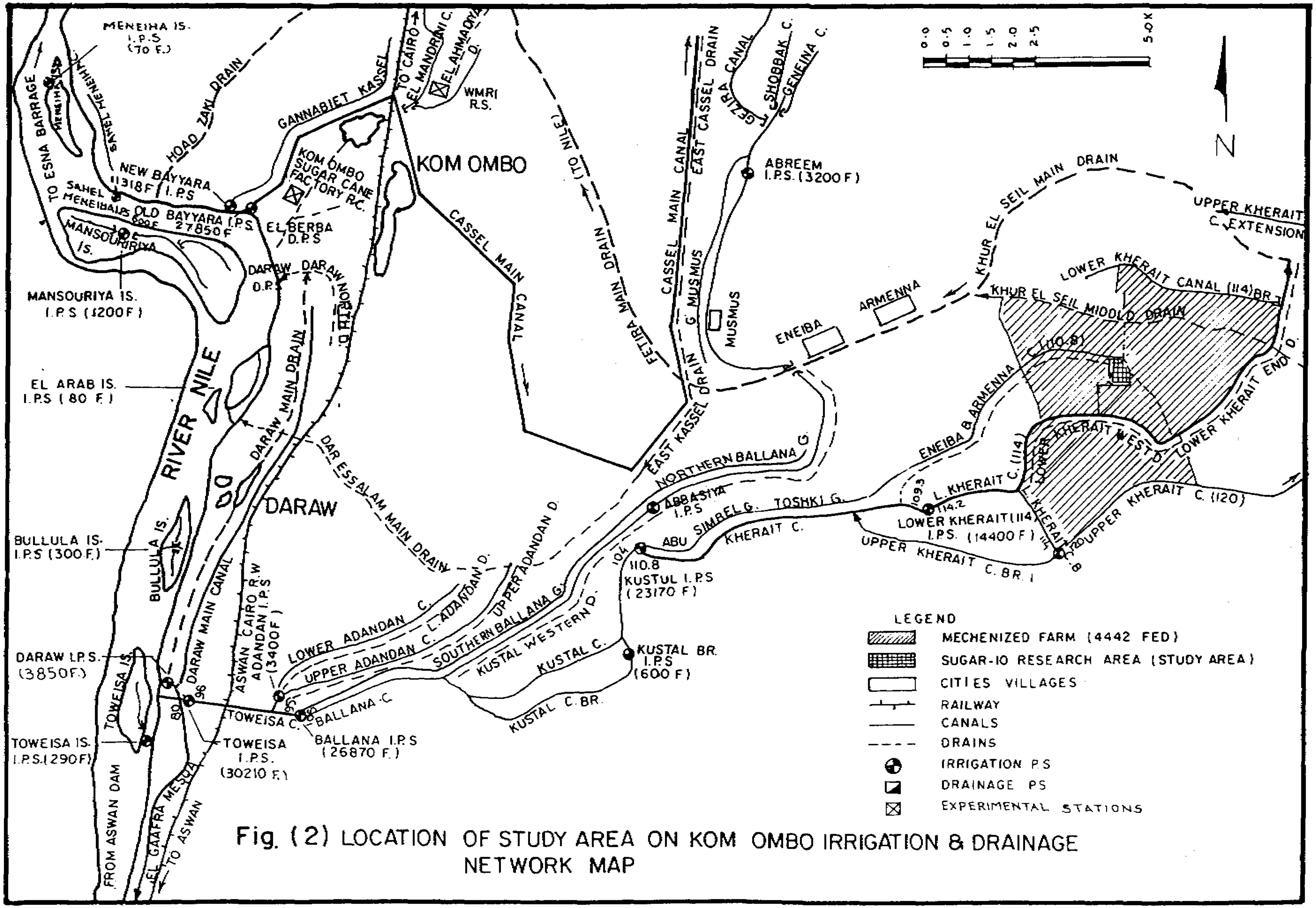

Fig. (2) LOCATION OF STUDY AREA ON KOM OMBO IRRIGATION & DRAINAGE NETWORK MAP

ENVIRONMENTAL IMPACT ASSESSMENT FOR SEWERAGE SYSTEMS

A.M. Mohorjy[1] and S.E. Awadallah[2]

ABSTRACT

The concept and procedures for environmental impact assessment (EIA) has been developed primarily as an aid to the environmental planning of new development projects or to the expansion of existing development projects. In this paper a sequenced approach for environmental impact assessment for sewerage system is outlined, describing existing environment; defining impacting activities and each component of the environment that will have possible affects; assessing the severity of impact and suggesting some mitigating measures.

1. INTRODUCTION

Many of the development projects in the past, and particularly those in the 1970's, have been implemented with little environmental concern. This is mainly due to the fact that knowledge of environmental impacts and impact assessment technology were not fully developed at that time. As a result, a number of large-scale development projects have led to adverse impacts of large magnitude. These adverse impacts have created strong feelings among people, awareness of environmental problems, and have led movements that promote environmental protection and protest against development.

While environmental impact assessment is of comparatively recent origin, the importance of preservation of environment and respect for nature have been the underlying principles of many cultures of various developing and developed countries.

During the 1970s and 1980s the interest in the awareness of environmental issues in developing countries increased significantly. The close interrelationship between environment and development came into sharper focus and became clearer than ever before. It is now generally accepted that environment and development are two sides of the same coin. In other words it is both desirable and essential to pursue the short and long term development goals while simultaneously ensuring sound environmental management.

The Environmental Impact Assessment (EIA) procedure has been developed primarily as an aid to the environmental planning of new development projects or to the expansion of existing development projects. It can be compared with similar techniques which have been devised for the technical and economic planning of projects, such as, financial feasibility studies. However, it differs from past technical and economic planning techniques in that it deals with the utilization of a common resource, such as, the environment. It is therefore appropriate that the procedure be

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mandatory, and be administrated by a public agency. It is important to understand where Environmental Impact Assessment (EIA) fits into the overall scheme of environmental management. EIA is essentially a preventative process. It seeks to avoid costly mistakes in project planning and development mistakes which can be costly, either because of environmental losses that result, or converts, because of costly modification that might be required to be made acceptable to the community.

Goals and Objectives of EIA can be summarized as follows:

i. To maintain a clean healthy environment;

ii. To maintain the quality of the environment relative to the needs of growing population;

iii. To minimize the impacts of the growing population and human activities relating to development actions e.g. mineral exploration; deformation, agriculture, urbanization, tourism and the development of other resources having an impact on the environment;

iv. To balance the goals of socioeconomic development and the need to bring the benefits of development to a wide spectrum of the population and assuming against the maintenance of sound environmental conditions;

v. To incorporate an environmental dimension in project planning and implementation by determining the implications of the proposed projects and costs of the required environmental mitigation;

vi. To promote greater cooperation and increased coordination among relevant agencies and authorities.

The ultimate aim of EIA is to ensure as fast as possible that all man's activities are in balance with his environment.

The following criteria may be applied in deciding if monitoring is required:

1. The impact and mitigating measures are not well understood.
2. Project construction and operation methods are not clearly described, or are experimental, or are subject to change.
3. The potential impacts on environments or natural resources are controversial.
4. Project scheduling is subject to change such that the impacts could be serious.

2. THE SCOPE OF ENVIRONMENTAL IMPACT ASSESSMENT STUDY

The study shall be undertaken in accordance with EIA guidelines as follow:

2.1 Establishing the Need of the Project:

In project planning it is important to establish clearly the need for the sewerage project. An explanation of why the project has been proposed indicates the aim of the project and helps to maintain direction during planning. A "Statement of Need" also highlights the social, cultural, economic or other benefits that will accrue from the project.

2.2 Description of Existing Environment (Base-line) (Affected Environment)

The environment as it exists prior to project development will be described fully by emphasising the environmental components that are of particular significance to the proposed project, both in the immediate environment and all ancillary areas that may be affected within the proposed site. Known present resources used in the area concerned will be described in qualitative and quantitative terms and knowledge gaps, where they exist, shall be identified.

However, an assessment of the project options (degree of treatment: preliminary, secondary, tertiary or advanced and sludge disposal) available is important right from the earliest stages of project planning. The environmental implications of each option should be considered while the options are still open. Major design and project siting options are assessed and eliminated, and an outline plan formulated in the project feasibility study. The environmental impacts generally associated with sewerage system project planning can be grouped into 3 categories which has a reciprocal relationship between its parts as given below and also see Fig. (1).

i. physical subsystem

ii. biological subsystem

iii. human subsystem

The various components under each subsystem can further be identified as below:

i) Physical subsystem:

- Wastewater flow velocities
- Ground water conditions
- Hydrology
- Wastewater quality
- Sediment
- Earth quakes
- Micro climate
- Local weather
- Evaporation
- Turbidity
- Water density

ii) Biological subsystem:

- Aquatic ecosystem upstream and downstream of treatment plant
- Nutrients
- Fish and aquatic vertebrates
- Aquatic vectors of disease
- Draw down zone
- Zone above high waterlevel
- Animals
- Phyto plankton
- Plants
- Drowned land
- Soils
- Plants
- Man

iii) Human subsystem:

Production of
- Fishing
- Energy
- Tourism
- Goods and commerce
- Ideas
- Administrative, social and economic status
- Agriculture
- Industries
- Communication
- Peoples
- Values

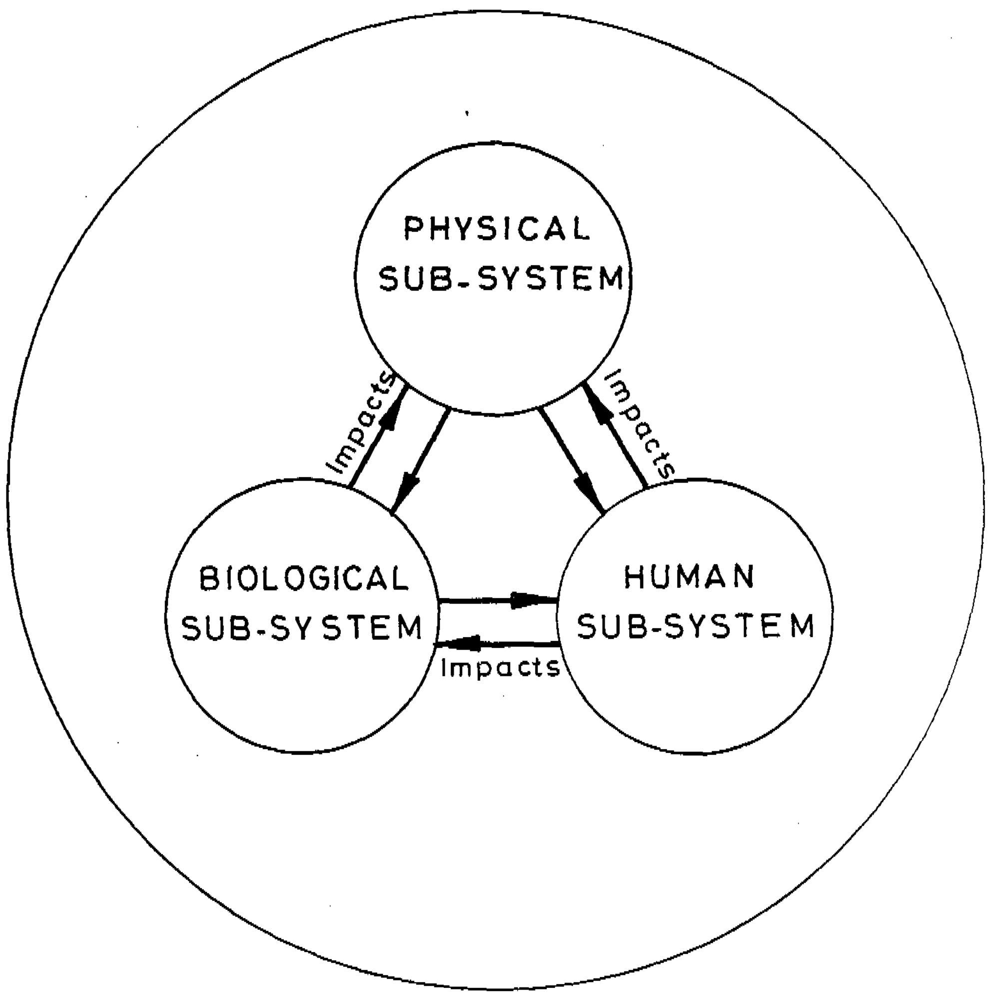

Fig. (1) Reciprocal Relationship between Groups of Impacts.

- Services: electricity, telephone, water mains ... etc.

After identifying the environmental impacts into 3 major categories with various components listed above, the next step will be to break the components into measurable parameters. This relates directly to data obtainable, in the field. However, some levels are more conceptual than measurable. By making measurements or collecting relevant data on each of the parameters reflecting environmental condition both 'with' and 'without' a project, it will be possible to perform an environmental assessment.

A listing of some suggested parameters for impacts due to sewerage system and water quality aspects are given below:

1. Sewerage Network (Collection system, transporting system, treatment plant, disposal system)

   - Area served by sewerage system
   - Volume of wastewater generated
   - Type and degree of treatment
   - Sludge disposal
   - Population served by sewerage system

2. Wastewater Characteristics

   - Flow
   - Interface land and water
   - BOD (Biochemical Oxygen Demand
   - COD (Chemical Oxygen Demand)
   - Dissolved oxygen (DO)
   - Inorganic carbon
   - Heavy metals
   - Petro chemicals
   - Streamflow
   - Total dissolved solids (TDS)
   - Turbidity
   - Clarity
   - Floating material
   - Coliforms
   - Inorganic nitrogen
   - Pesticides
   - pH
   - Temperature
   - Toxic substances

3. Land

   - Soil erosion
   - Shoreline
   - Compatibility of land use
   - Flood plain usage
   - Soil suitability for use as land treatment
   - Solid waste disposals

4. Ecological

   a) Species and population

   - Games and non game animals
   - Managed vegetatio
   - Resident and migratory birds
   - Natural vegetation
   - Pest species
   - Sport and commercial fisheries

   b) Habitats and communities

   - Species diversity
   - Rare and endangered species
   - Food chain index

   c) Ecosystems

- Productivity
- Energy flow
- Biogeochemical cycling

5. Aesthetic

   a) Land

   - Geological surface material
   - Relief and topography

   b) Biota

   - Animals, wild and domestic
   - Vegetation diversity
   - Vegetation type

6. Social

   a) Social

   - Educational/Scientific
   - Historical
   - Cultural
   - Leisure/recreation areas

   b) Individual well-being

   - Physiological health
   - Safety
   - Psychological health
   - Hygienic

   c) Community well-being

   Community well-being

   d) Social interactions

   - Political
   - Religious
   - Economic
   - Socialization
   - Family

The above suggested list can be improved as more informations are obtained and better indicators of environmental quality are developed. This indicator list provides only the basic blocks and does not include the interactions and linkages.

To develop the parameter data needed to provide a basic for environmental assessment, the following steps for each alternative plan (Full sewerage system, drainage system (vertical and/or horizontal) and septic tanks) are to be taken.

1. Collect the data and measure each parameter of environmental quality in the pre-plan conditions.

2. Extrapolate current conditions into the future on a parameter by parameter basis for estimating the future condition of environmental quality "without the project".

3. Estimate future conditions of environmental quality "with" the project on a parameter-by parameter basis.

4. Determine the difference in environmental quality between the "without" and "with" project conditions, and indicate beneficial or adverse impacts respectively.

2.3 Impact Prediction and Interpretation

A further reason for assessment at an early stage of the project planning, is to enable the planner to identify and to incorporate into his plan any design components or modifications which will mitigate or abate potential adverse environmental impacts. However, identification of environmental protection measures, is only part of the task. Assessors must also see to evaluate those measures.

This activity should involve quantitative predictions of expected environmental changes resulting from the proposed project. If quantitative predictions are not possible, the anticipated changes should be qualitatively described. This activity is the most important technical activity in the EIA process. The fundamental reason for the environmental impacts is the potential of long term and the intangible effects.

Several levels of technology may be used for impacts prediction, and these can be considered in three categories:

1. Usage of interaction matrices

2. Usage of mathematical models, and

3. Usage of empirical assessment methods.

Interaction matrices were one of the earliest types of methodologies utilized in environmental impact studies [Leopold et al. 1971]. A simple matrix refers to a display of a project actions or activities along one axis, with appropriate environmental factors listed along the other axis of the matrix. When a given action or activity is anticipated to cause a change in an environmental factor, this is noted at the intersection point in the matrix and further described in terms of magnitude and importance consideration. Many variations of the simple interaction matrix have been utilized in environmental impact studies.

Mathematical models refer to predictive techniques that use mathematical relationships between system variable to describe the way an environmental system will react to an external influence. Some empirical assessment methodologies also can be used according to the function and type of the proposed project.

a) Bio-physical environmental impact

Based on existing data and information, predictions will be made of the environmental impact of the proposed project which can arise from technical shortcoming and human error, or a combination of both. Also to be included will be information about the sludge release from the proposed project development, the ambient levels in the study area, and data on the local climate and topography, predictions on the likely pattern and level of pollution shall be made.

b) Socio-economic Impact

Socio-economic impact can be measured in short and long terms. On the basis of socio-economic baseline and the characteristics of the proposed development, the effects of establishing and operating the proposed project shall be predicted.

2.4 Interpret Predictions

This activity in an environmental assessment study is very important in that the significance of the anticipated impacts is determined. Combinations of three basic approaches can be used to interpret the predicted impacts of any proposed project or development action.

1. Compliance with environmental laws, regulations, and executive orders (the institutional approach);

2. Professional judgment of members of the environmental assessment interdisciplinary team (the technical approach); and

3. Public concerns and interests (the societal approach).

The institutional approach can be based on identified requirements as accomplished in activity 2. Considerable detail can be found in numerous environmental media laws and policies for environmental preservation and enhancement, and these will differ from country to country.

2.5. Identify and Evaluate Mitigation Measures

Impact mitigation represents a broad concept that includes a number of issues. For example, the Council on Environmental Quality (CEQ) in the United States has indicated that impact mitigation may include one or more of the following ("National Environment" 1978):

1. Avoiding the impact altogether by not taking a certain action or parts of an action.

2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

4. Reducing or eliminating the impact over time by preservation and maintenance operations during the lift of the action.

5. Compensating for the impact by replacing or providing substitute resources or environments.

Fundamentally, this activity involves the identification and evaluation of pertinent mitigation measures.

2.6. Monitoring Environmental Impacts

Environmental impact assessment baseline studies may be initiated as part of the environmental data collection programme. Where significant residual environmental impacts are predicted there would be a need for the project initiator to continue these studies as part of monitoring programme. Such programmes perform two important functions:

1. They provide a check on the environmental management of the project and ensure that project initiator meets the conditions attached to the approval given for his project.

2. They provide feedback to improve the data base for environmental impact prediction in future project planning.

2.7. Trade-Off Analyses and Selection

Even though it may not be possible to place an economic value on the environmental losses or gains resulting from a sewerage project, decision makers (project planners and project approving authorities) must take into account implied environmental values in their decision-making. To facilitate the decision making process therefore, assessors of conducting environmental impact assessments must not just identify environmental impacts; they must also provide information on the implied values of environmental losses and gains.

The U.S. Council on Environmental Quality Regulations highlights the importance of the assessment of alternatives by noting that this represents the "heart of the environmental impact statement" ("National Environment" 1978). The regulations indicate that information on the environmental impacts of the proposal and the alternatives should be presented in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision makers and the public. As an example, in the case of a proposed wastewater treatment plant, several alternatives may exist; these can be considered in the following categories:

1. Site alternatives for treatment plant

2. Facility size and design alternatives (type of treatment used)

3. Impact of mitigation alternatives

4. Facility operational alternatives (for different parts of the collection, transporting and disposal system)

From a conceptual perspective, trade-off analysis as used herein typically involves the comparison of a set of wastewater treatment alternatives relative to a series of decision factors. A trade-off matrix for systematically comparing the groups of alternatives or specific alternatives within a group is relative to a series of decision factors, such as:

Degree of meeting need.
Economic analysis.
Social concerns (public preference)
Environmental Impacts

* Air quality
* Surface water (long term enhanced water quality)
* Ground water
* Noise
* Biological habitats
* Cultural resources (distraction of historic or archaeological sites)
* Socioeconomic (includes health, relocation of population)
* Noise
* Odor and smell

The information in this table can be descriptive or quantitative. Multiatribute or multicriteria decision-making techniques can be used to select the preferred alternative. Such techniques can include the assignment of importance weights to decision factors and/or the ranking or rating of each alternative relative to each factor (Keeney 1980). Five alternatives exist, which could be for different sites, different designs at a given site, different impact mitigation measures for a given design at a site, and/or different operational procedures for given site, design, and mitigation measures.

Avoidance of adverse environmental effects, some or all through preparation of a cost-benefit analysis may be feasible.

3. SUMMARY

A methodological framework for planning and conducting environmental impact studies for proposed wastewater project has been presented herein. There are 7 suggested activities in the framework, with the activities divided into determining the need and design features for alternatives under consideration, preparing a description of the affected environment, prediction and interpretation of impacts on various environmental resources, decision making to produce a proposed action, and environmental monitoring. The technical focus of the methodology is on quantifying, if possible, or at least qualitatively describing, the anticipated impacts on air quality, surface and ground-water quality, noise, biological habitats, threatened or endangered species, historic or archaeological sites, and socioeconomic characteristics, including transportation, land use, loss of land through flooding, health, and safety. Mitigation of undesirable impacts should also be addressed for each alternative site, design, and operational pattern, and particularly for the proposed action. The activities can be modified and adapted to meet the specific needs of a particular study and a particular geographical area.

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COOLING EFFECT OF A RIVER OR A CANAL ON THE MICRO-CLIMATE IN URBAN AREA

Kazutoshi KAN [1] and Yoshihisa KAWAHARA [2]

To evaluate the effect of river and canal on thermal environment, field observations at the Tama River and the Shibaura canal were performed. The detailed measurement of vertical temperature distribution within the river and the canal and measurement of urban temperature along the street crossing the river and the canal were carried out and horizontal extent of cooling effect were confirmed by these observations. In the Tama River, the cooling effect is restricted in day time, while in the Shibaura Canal, this cooling effect appeared in night time.

Pour évaluer l'effet d'une rivière ou d'un canal sur l'environnement thermique, une étude sur le terrain ont été effectuée pour la rivière de Tama et le canal de Shibaura. Les températures dans la rivière et le canal, ainsi qu'à leur alentours ont été mesurées en détails. L'effet horizontale de la rivière ou du canal sur l'environnement thermique est confirmé par la présente étude. De la rivière cet effet de refroidissement est présent pendant la journée. Par contre, il existe pendant la nuit dans le cas du canal.

1. INTRODUCTION

Rivers and canals in cities are the last open space left in urban area. They are precious and hydroliphic. As targets of comprehensive management they are being paid increased attention in rapidly urbanized area. Close to rivers it is possible for people to indulge themselves with the fresh air in summer. In suburban area the temperature can be several degrees lower than in the city. It can be said that the thermal environment is strongly influenced by the urban structure, trees and water. In a city like Tokyo where the energy consumption is concentrated, with increasing construction activities the heat-island phenomenon appears, and the number of hot nights in summer increases. Consequently the thermal environment is deteriorating. Urban rivers, apart from their positive visual and psychological effect, have served as cooling sources in summer and bring down the surrounding temperature due to the wind blowing over the wide river space. From our measurements of the temperature distribution along rivers, it is found that the temperature near a river is lower, showing thus the river's effect on the thermal environment. However, this effect is related to the surrounding topography and the urban structures. It is argued that past measurements and the data collected are insufficient.

In order to evaluate urban rivers' effect on the local climate, based on which to map out ways to improve the urban environment, it is necessary to quantitatively investigate the thermal effects of different water bodies.

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In this paper, to study quantitatively water bodies' effect on their surrounding area's summer micro-climate, we carried out two kinds of temperature measurements:

1) to evaluate the water bodies' effect on their surrounding temperature, we measured the temperature at two sites. One is the Tsurumi River and its immediate inhabitant area which is crowded, the other is the Shibaura Canal which is surrounded by buildings.

2) to evaluate the effect of the cool sources-water surface and the river's flood plain, we measured the transverse temperature distribution, in the Tama River that has wide flood plains and natural river patterns, and in the Shibaura Canal along which there is an artificial park.

All the measurements were carried out during 24 hours, and the temporal variations of the water bodies' effects are examined.

2. FIELD MEASUREMENTS

For the measurements in the Tsurimi River, four cars run on existing, separate roads, and thermal meters fixed on the cars were used to take the temperature at different locations, with an interval of one hour. To protect a sensor from sunshine effect, part of it was fixed in a styrene foam cylinder, which in turn was attached to a rod from the car's roof. In the Shibaura Canal (in the following we shall refer it as "the Canal"), measurements were carried out using a bike, and the same sensor as employed in the Tsurimi River. The air temperature was measured at two points: 0.5m and 1.5m from the surface, respectively.

The vertical temperature distributions in the Tama River and the Canal were measured by the thermal meter partly hidden inside the styrene foam cylinder, as mentioned above, the cylinder itself was fixed in a pipe, the latter being suspended from a bridge. The temperature was measured at points 0.3m, 0.8m, 1.5m, 2.5m, 3.5m, 4.5m, 5.5m and 6.5m from the water surface or the flood plain. In the Tama River there were 20 vertical temperature profiles measured across the section, and 22 vertical temperature profiles measured in the Canal. The measuring station for the Tama River, located in the tidal zone which is 10.5km from the river mouth, has a varying distance from the bridge due to the tidal effect. Since this distance from the bridge was on the average 11m, it was impossible to measure the temperature from the water surface to the bridge. For the flood plain part, it was possible to measure the temperature from 0.3m above the surface up to the bridge. In accordance to the measurements inside the river, the temperatures at 0.5m and 2m above the bridge were also measured. In order to evaluate the river's influence, temperature was also measured at fixed points along the the roads extended from the bridge. The measurements were conducted every 3 hours for 24 hours. For the Canal, the measurements were carried out using the existing bridges along the Canal (where riparian works also exist). Outside the Canal, the thermal meter was installed vertically to conduct the measurements.

For the Canal, an ultra-red thermal image apparatus (by Japan Avionics TVS-2000ST) was used to detect the surface temperature. The same instrument was also employed in the Tama River to measure the surface temperature variations caused by the riparian works on the flood plain. All these field data were used to compare the thermal effects in different water bodies'. The results from these comparisons should provide useful information for future works along rivers and canals. Due to space limit here we shall discuss the results of the vertical temperature profiles measured in the Canal and in the Tama River.

3. RESULTS AND DISCUSSION

3.1 Temperature Distributions in the River and the Canal

First we shall examine the temperature distribution in the River. On Sept. 2 and 3, 1992, when the measurements were conducted, and there was strong sea wind blowing along the river. In Figure 1 are shown the typical temperature distributions during day time and night time. At PM1:00, the temperature distribution was quite uniform in the main channel, while it became rather complicated on the flood plain and water surface. In the night, the temperature distribution was almost uniform across the measuring section, including the flood plain. Figure 2 shows the difference between the average temperatures (for day time from AM 5 to PM 5 and from PM 7 to AM 3 for night time), and the temperature taken 600m away from the bridge, in the street (referred as T_s). During the day time, while the temperature near the water surface in the main channel was 1.2-0.8°C lower than the one in the street, the temperature on the flood plain was a little higher, 0.8-0.4°C lower than the one in the street. Thus the temperature in the river as a whole was lower than in the street, showing that the river serves as a cooling source. The lower temperature effect during the day was not observed at night. Particularly the difference of the temperature in the main channel and the one in the street became smaller, while on the flood plain the low temperature area was enlarged, giving it a larger effect as a cool source. The average temperature during a whole day(24 hours) was still lower in the river.

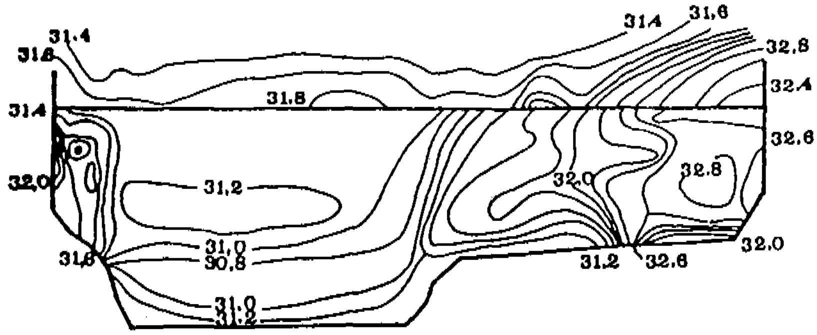


Figure 1(a) Temperature Distribution in Tama River (PM:00)

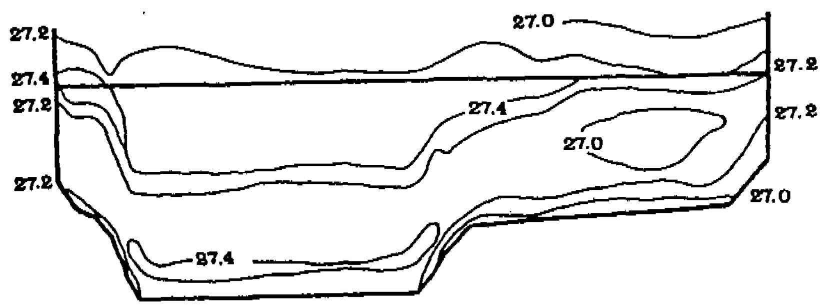


Figure 1(b) Temperature Distribution in Tama River (AM0:00)

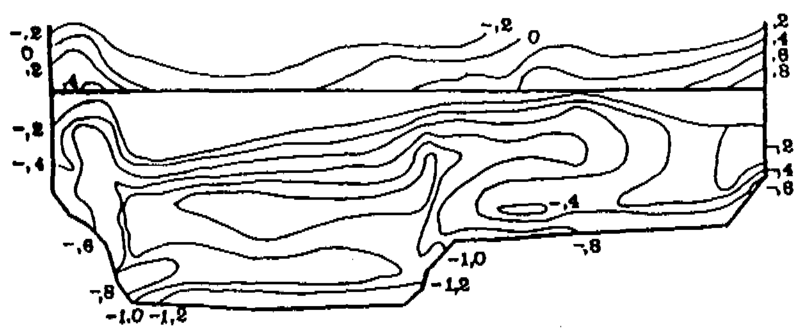


Figure 2 (a) Tama River's Temperature as Compared with Street Temperature
(day time average)

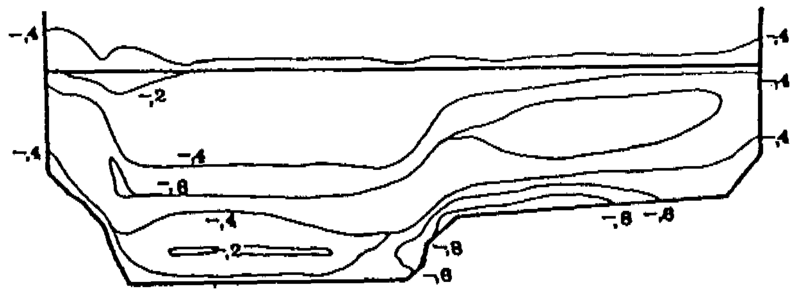


Figure 2(b) Tama River's Temperature as Compared with Street Temperature (night time average)

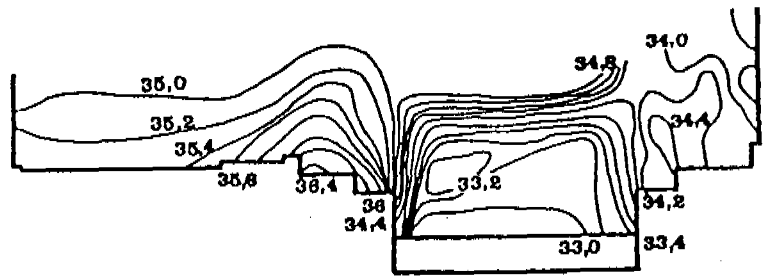


Figure 3 Temperature Distribution in Shibaura Canal (day time average)

Next the average temperature during the day time for the Canal is given in Figure 3. In Figure 4 is shown the difference of the temperature in the Canal (T) and the one 2m above the center of the bridge (T_{bs}), with the results from day time shown in Figure 4(a) and those from night time shown in Figure 4(b). During the day, this difference ($T-T_{bs}$) varied a lot from the Canal to the neighboring park (on the left), and to the road (on the right). While in the Canal the temperature was lower than above the bridge, the temperature in the park was higher than T_{bs}, showing stronger effect from the park's surface than from the water body. The weak wind on the days of measurement (Sept.4 and 5,1992) is believed to have partly contributed to this result. it was surprising to observe high temperature in the riprap close to water. This shows that although tile bank may be good for the scenery, it is bad for the thermal environment. During the night the temperature distribution was quite uniform. Compared with the Tama River which has wide flood plain and sea winds, the Canal surrounded buildings in urban area is not influenced by sea wind. Nevertheless, it remains a cool source. The cooling effect, however, is limited to its immediate surrounding area.

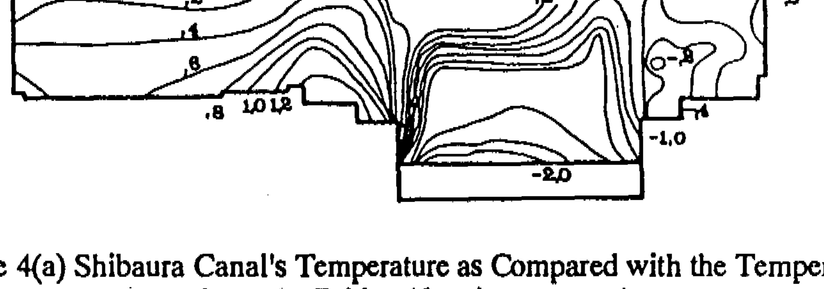


Figure 4(a) Shibaura Canal's Temperature as Compared with the Temperature above the Bridge (day time average)

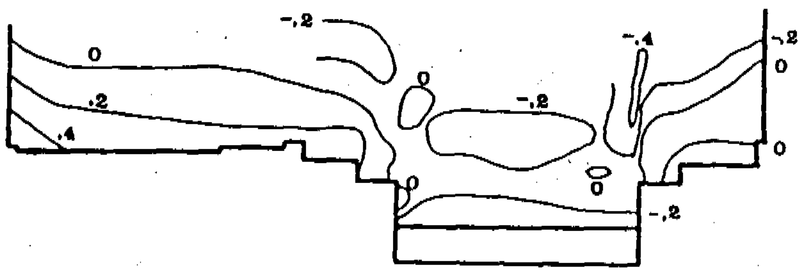


Figure 4(b) Shibaura Canal's Temperature as Compared with the Temperature above the Bridge (night time average)

3.2 Temporal Variation

In Figure 5 are shown the temporal variations of the vertical temperature distributions above the bridges' centers in the Tama River and the Canal. The upper part in the Figure s shows the difference between the temperature at different height and the temperature above the bridge (T_{bs}), the lower part gives the difference between the water surface temperature and T_{bs}. The symbol ▲ means negative value, the bigger it is the larger the temperature difference ($T-T_{bs}$). In both the Tama River and the Canal, with the water surface temperature becoming lower than the one above the bridge, the temperature distribution also becomes lower than T_{bs}. For the Canal, the temperature difference on the water surface and above the bridge was large. Thus, the temperature in the Canal was lower, except during the night when the water surface showed higher temperature than T_{bs}. Similar distribution was observed on the flood plain of the Tama River (Figure 6a). The air temperature on the flood plain shows the same variation as that of the water temperature. However, Figure 6b, which gives the temperature distribution in the park along the Canal, shows that the air temperature did not change with the change of the water surface temperature. This indicates that the Canal does not have direct thermal effect on the park.

To see the correlations among the water surface temperature, the air temperature immediately over the water surface and the air temperature over the bridge,($T_{0.3}-T_{bs}$) is plotted versus (T_{ws} - T_{bs}) in Figure 7, where m represents day time data, and for night time data.In the Tama River , air temperature immediately over the water surface showed no change when the difference between the water surface temperature and the air temperature above the bridge was less than 2°C, above which the cooling effect becomes evident, and the temperature of the air over the water surface decreases with decreasing water surface temperature.

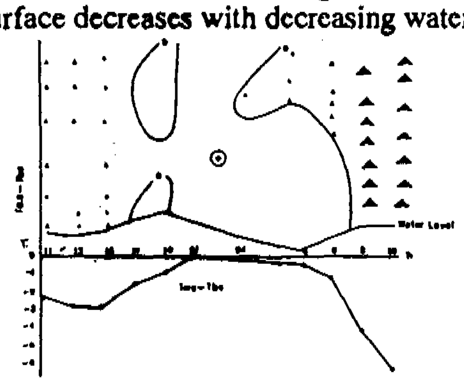


Figure 5(a) Temporal Variation of the Temperature Distribution (main channel of Tama River)

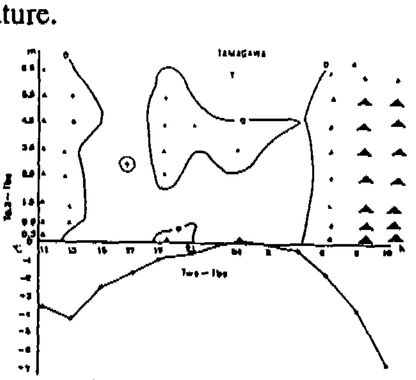


Figure 6(a) Temporal Variation of the Temperature Distribution (flood plain)

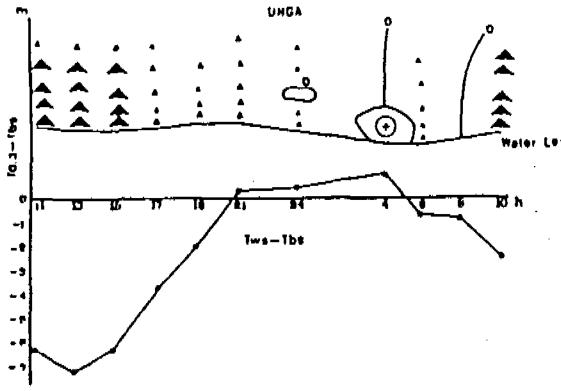


Figure 5(b) Temporal Variation of the Temperature Distribution (the Canal)

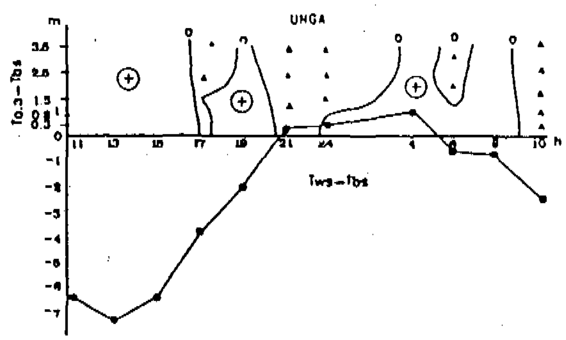
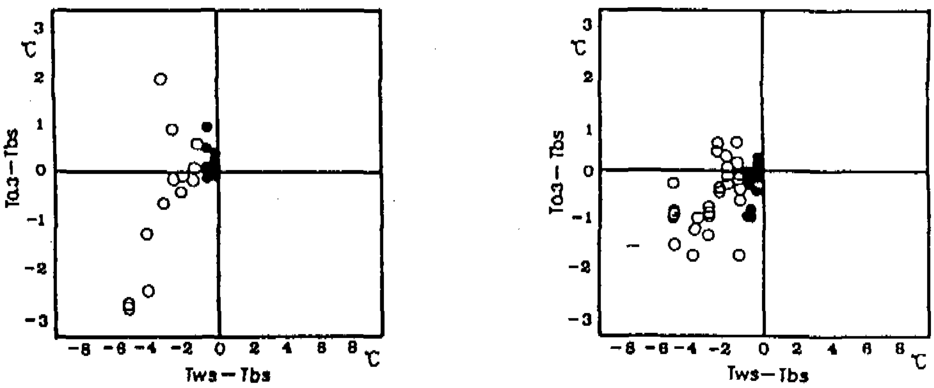
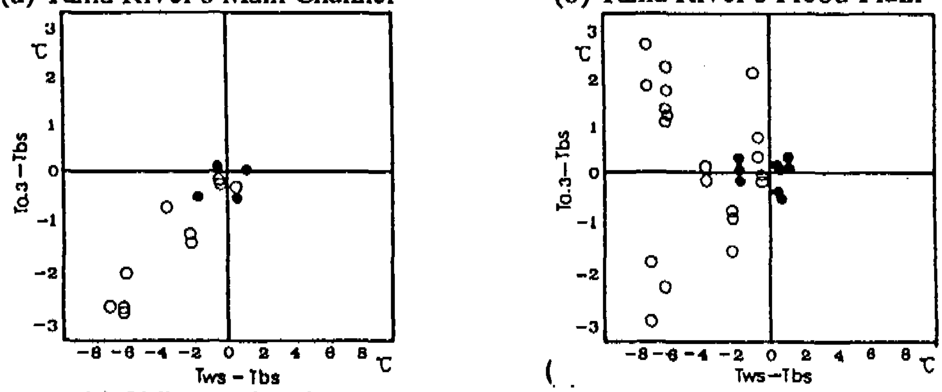


Figure 6(b) Temporal Variation of the Temperature Distribution (park along the Canal)

In the Canal, the air temperature above the water surface changes with the water surface temperature. In a similar way, data from the flood plain (in the Tama River) and the park (along the Canal) are shown in Figure 7(b),(d) , where the vertical coordinate represents the difference between the temperature 0.3m above the surface and that above the bridge. While the Tama River's flood plain data demonstrate the same tendency as in the main channel, the data from the park along the Canal show completely different trend. This is due to the fact that the tiles in the park were of high temperature during the day, as mentioned above.



(a) Tama River's Main Channel (b) Tama River's Flood Plain



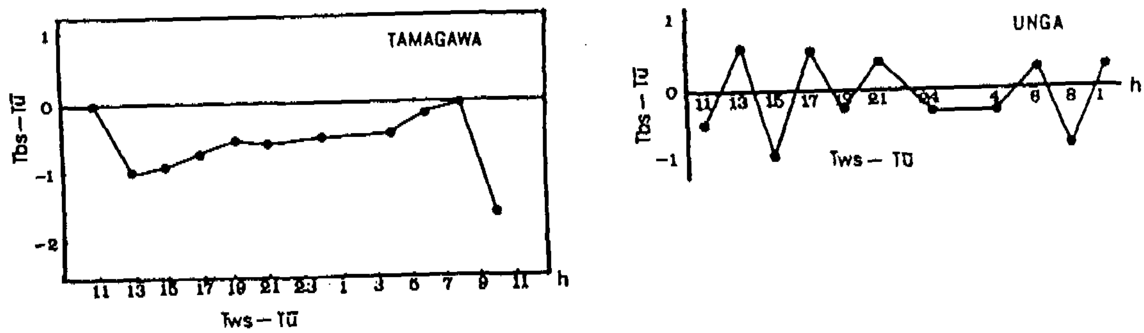
(c) Shibaura Canal (d) Park along the Canal

Figure 7 Correlation between the Water Surface Temperature and the Air Temperature above the Surface

3.3 Cooling Effect on the Surrounding Streets

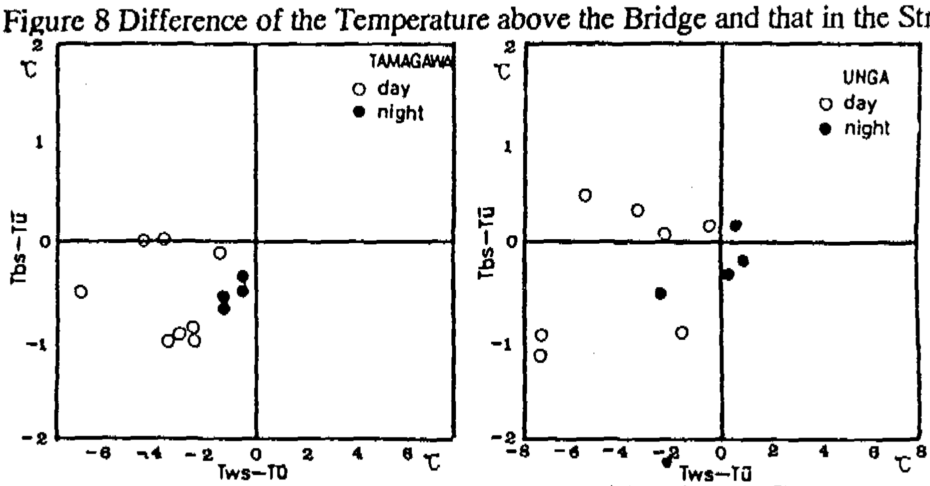
It has been shown above that the air temperature over the water surface and that above the soil surface vary with the water surface temperature. In order to see how much this cooling affects the temperature in the streets beyond the levees, the daily variation of the difference between the air temperature 2m above the bridge's center and that in the streets is shown in Figure 8. In Tama River, wind temperature above the bridge was lower than the street temperature during the whole day, showing thus the river's cooling effect was carried by the wind to the surrounding streets. This effect was larger during the day when there was strong sea wind, compared with that during the night when the wind was weak. In the Canal the sea wind was weak (no strong sea wind was observed), the temperature over the bridge was not so low. It is believed that due to the weakness of the wind, the Canal's cooling effect could not reach beyond the bridge. This shows the importance of wind in carrying the cooling effect to the streets, thus the importance of having reliable urban structures to bring in sea wind.

Data in Figure 8 are replotted in Figure 9, where the horizontal coordinate represents the difference of the temperature in the streets and the water surface temperature, the vertical coordinate indicates the difference of the air temperature 2m above the bridge and that in the streets. From the Tama River results one sees that the air temperature above the bridge was lower than the water surface temperature. On the other hand, in the Canal the correlation between the water surface temperature and that above the bridge was low, indicating little cooling effect on the streets.



(a) Tama River (b) Shibaura Canal

Figure 8 Difference of the Temperature above the Bridge and that in the Street



(a) Tama River (b) Shibaura Canal

Figure 9 Correlation between the Water Surface Temperature and that above the Bridge

Figure 10 shows the surface temperature in the Canal as well as in its surroundings, measured by the ultra-red thermal image instrument. During the day time, the part of tiles in the park was of high temperature, where the air temperature was dominated by the heat rendered by the tiles in the park. During the night, however, radiation effect cooled down the tiles and the temperature distribution became uniform.

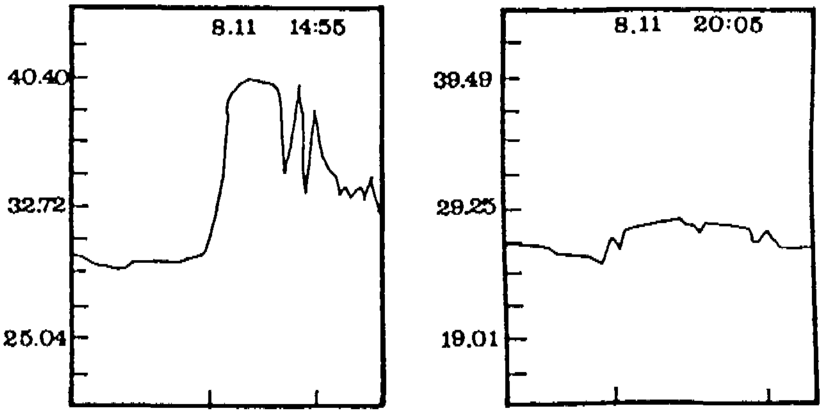
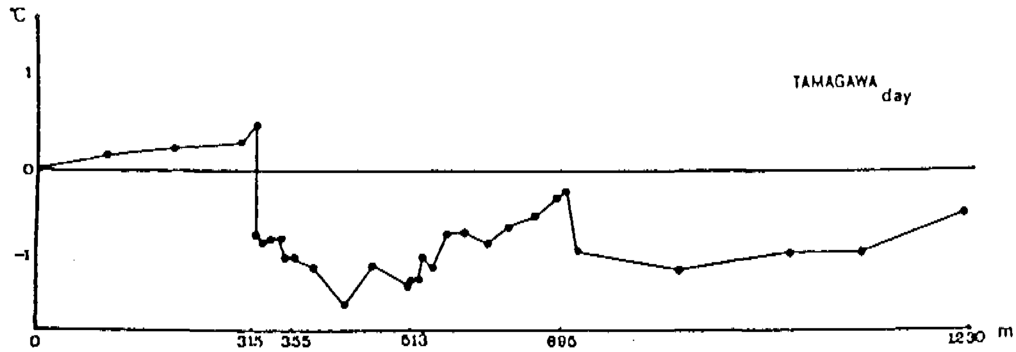


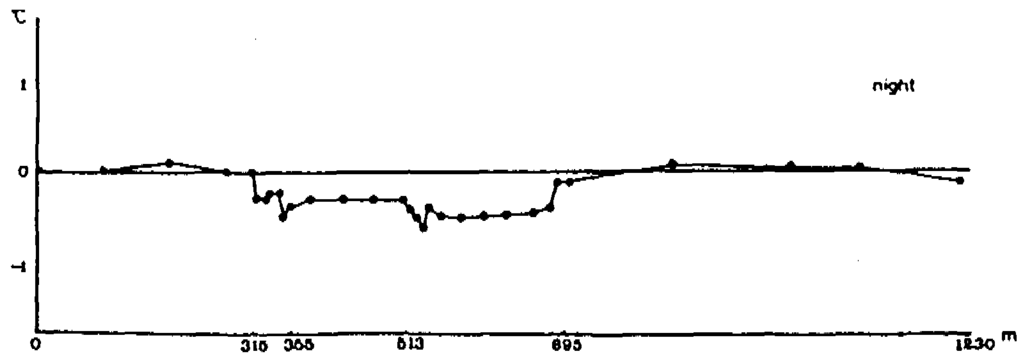
Figure 10 Surface Temperature (the Canal)

3.4 Influence Zone of the River and the Canal

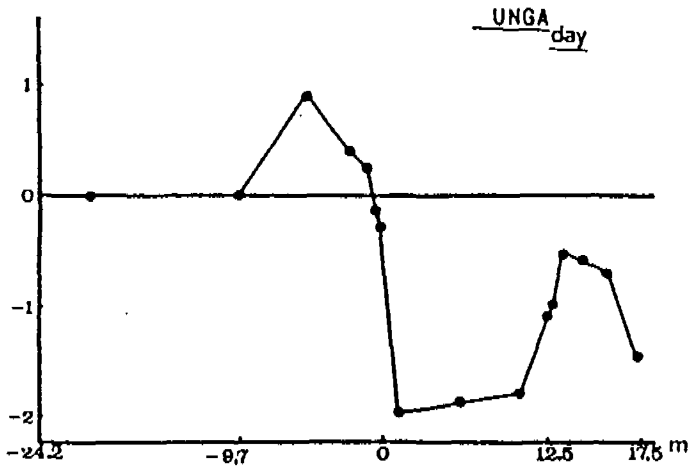
As shown above, in the Tama River which has wide flood plain, both the water surface temperature and the air temperature above the bridge were lower than the street temperature. The River serves as a cooling source, the effect being larger during the day. To see how far away into the streets this effect reached, we measured the air temperature along the bridge and the connecting roads by riding bikes. The results for both the day time and night time are given in Figure 11. During the day time, the Tama River's both banks had higher temperature than the surrounding. To the left bank there were trees along the sidewalks, and the measuring points were under the trees, rendering thus lower temperature than on the right bank side. Also, closer to the River the temperature became lower. With the wind blowing from the River to the streets on the left bank side, the cooling effect reached up to 600m. On the right bank side, since the wind blew from the streets to the River, the cooling effect did not reach the right bank side. In the case of the Canal, the park showed high temperature, and there no cooling effect was observed. During the night, the Tama River's cooling effect reached to the nearest 200m only. This was due to the weak wind as well as the smaller difference between the street temperature and the water surface temperature. On the contrary, the park along the Canal during day time was of relatively low temperature and it became a cooling source.



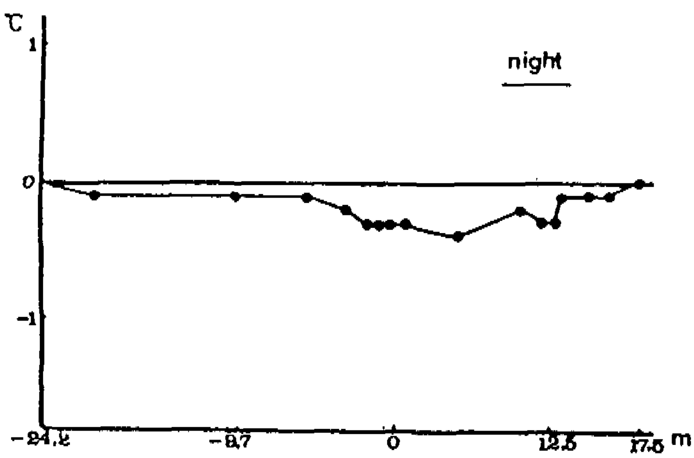
(a) Day time average (Tama River)



(b) Night time average (Tama River)



(a) Day time average (Shibaura Canal)



(b) Night time average (Shibaura Canal)

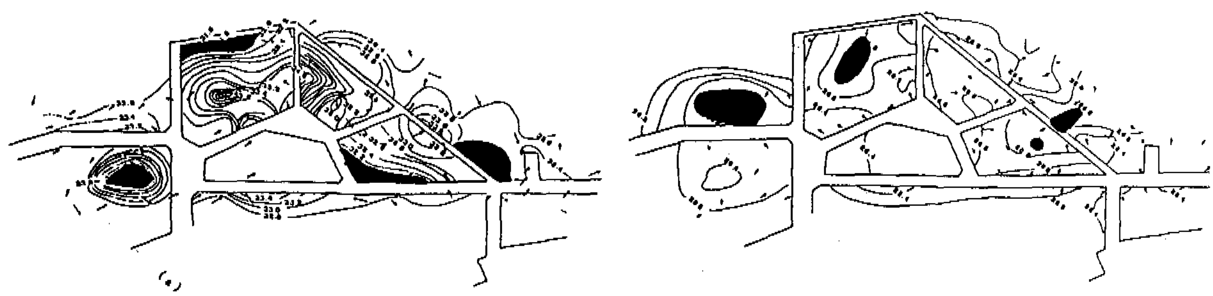
Figure 11 Lateral Variation of the Difference between the Air and Street Temperature

4. LAND USE AND THE THERMAL ENVIRONMENT NEAR A CANAL

The mechanism of a river or a canal's cooling effect as well as the range of its influences have been examined. How much does this cooling affects the surrounding temperature has also been analyzed through 1-D modelling of Shibaura Canal's thermal environment.

4.1 Temperature Distribution and Land Use

The daily variations of the temperatures along the canal were measured in August, 1992. Portable digital thermometers were employed to take the temperatures once every hour at about 80 different places, during 24 hours. The corresponding wind directions and wind speeds were also measured. The contours of the day-time and night-time average temperatures are given in Figure 12, where shown in black represents lower temperature in day time and higher temperature in night time. That the temperature in day time along the canal was lower was but a local effect. While in night time, low temperature also appeared away from the canal, showing diminishing cooling effect of the canal. Thus the canal's cooling effect exists only in day time and it was limited to the canal's immediate surrounding area. Since the wind was weak when the field measurements were conducted, and there are high buildings nearby, it is considered that the cooling effect could not reach out.



(a) Day-time average (b) Night-time average

Figure 12 Temperature Distribution along the Canal

The above shows that it is necessary to consider the urban structures when assessing a canal's cooling effect. The index for urban structures is the Sky-view factor, as shown in Figure 13, in which white part surrounding the canal indicates low Sky-view factor. Figure 14 shows the classification of land use, from which it can be seen that it is difficult for the cooling effect to be propagated laterally. When assess the cooling effect it is necessary to consider the vertical dissipation along the high buildings.

In Figure 15 is given the temperature at AM12, in November 11, 1993, versus the Sky-view factor, indicating rather good correlation. Consequently, when examining the local thermal environment, it is necessary to take into consideration the surface conditions, the land uses and Sky-view factor etc..

4.2 Land Use and Energy Balance

The differences in the energy budget, in case of water surface, concrete surface and bare surface, have been examined. In the case of bare surface, an observation tower 6m high was set up, and the vertical distributions of the wind speed, humidity and temperature were measured continuously. Radiation was also determined. Using the Bowen-ratio method and the data of wind speed (the part which follows the log-law), temperature and humidity, sensible and latent heat fluxes were calculated (Figure 16). R stands for the pure radiation quantity, G is the flux into the earth, H and E are sensible and latent fluxes, respectively. Shown in Figure 16 are the data obtained in summer, 1993, when the weather was not good and the observation difficult. In the day of measurement, it started to rain in the evening, and no observation was possible in the night. With the Albedo value from this measurement, and the wind and temperature data observed at Tokyo Tower, as the boundary conditions, 1-D calculation was carried out and the results are shown in Figure 17. Though differences do exist, the tendencies are correctly simulated. This 1-D model was used to examine the canal's cooling effect. Calculations were done considering surface conditions, land uses, energy from human activities, of which the results of water surface energy balance are given in Figure 18. Although the heat conductivity is large on the water surface, most of the pure radiation was absorbed into the water, the cooling effect of the water surface is well reflected in the energy balance.

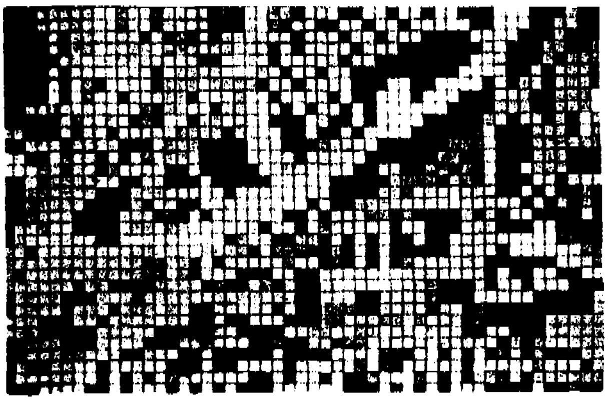


Figure 13 Sky-view factor

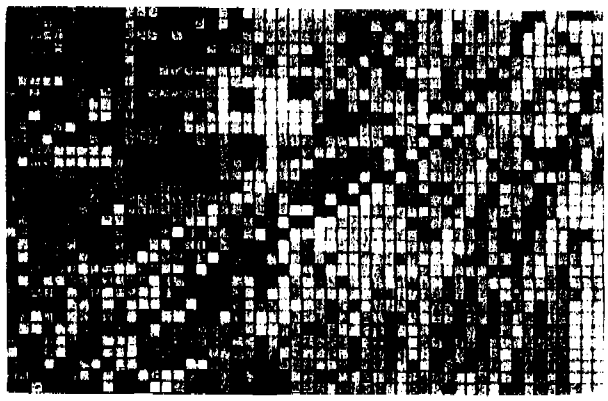


Figure 14 Classification of Land Use

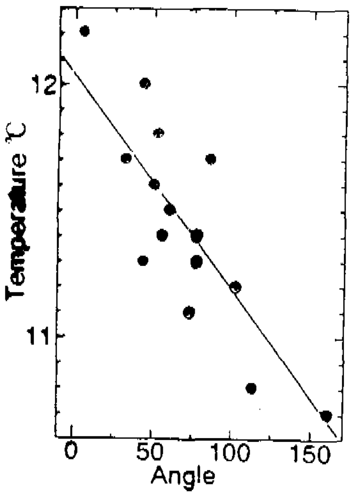


Figure 15 Sky-View Factor versus Temperature

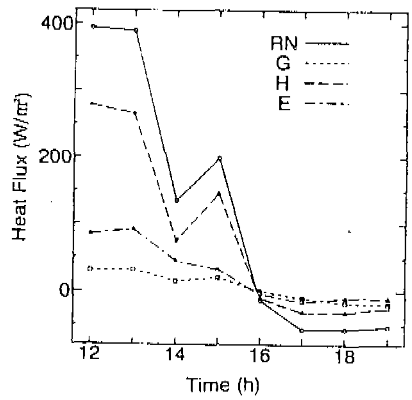


Figure 16 Energy Balance, Measured (bare surface, 09.28.93)

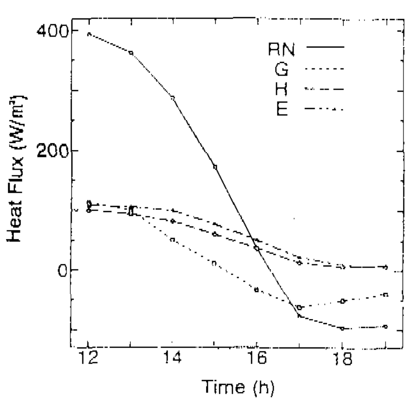


Figure 17 Energy Balance, Calculated

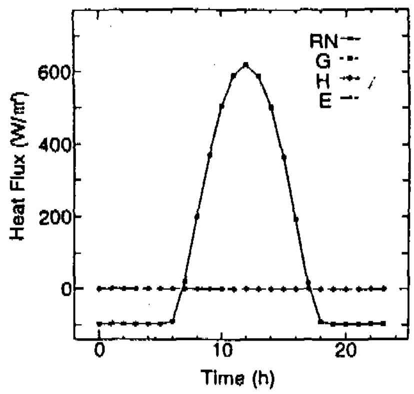


Figure 18 Energy Balance on the Water Surface

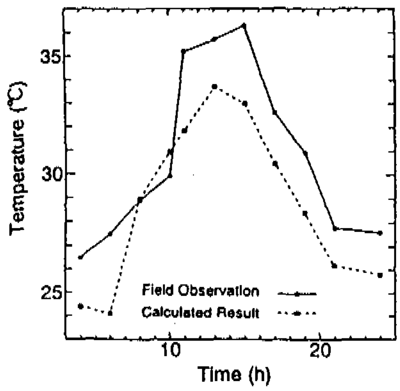


Figure 19 Daily Temperature Variations

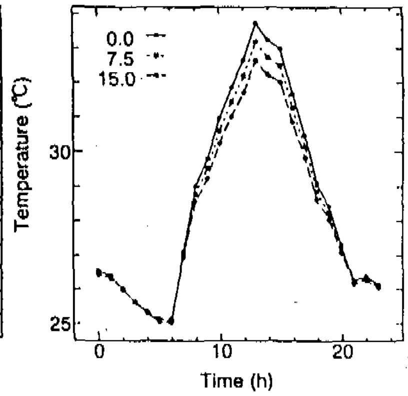


Figure 20 Canal's Cooling Effect

4.3 Canal's Cooling Effect

For the range as represented in Figure 13, the observed daily temperature variations 2m from the surface are compared with those calculated, in Figure 19. If one notes that the observed data were from the pedestrian along the canal (thus showing higher temperatures), it can be considered that the calculated results agree rather well. The same model was used to examine the canal's effect, and the results are given in Figure 20. In Figure 20, 0.0 represents the daily temperature variation without the canal, 7.5 for the case when the canal area occupies 7.5% of the total area under examination, and finally, 15% for the case when the canal water surface extends to 15% of the total area. It is seen that the canal's cooling effect exists only during the day time, being of 1°C. This agrees well with what was observed from the field data.

5. CONCLUSIONS

In order to evaluate quantitatively the cooling effect of rivers and canals during summer, we have measured the vertical air temperature distributions in two types of water bodies', namely: the Tama River which has wide flood plain and the Shibaura Canal which is surrounded by buildings. A thermal image instrument was also used. The results obtained may be summarized in the following:

1) In the Tama River which has wide flood plain, the average air temperature was lower than the surrounding street temperature during day time and night time, the River is a cooling source for the streets. This effect was strongly influenced by the sea wind.

2) Though the Shibaura Canal flowing through resident area had lower temperature than in its surroundings, the effect of sea wind was small. During day time, its cooling effect was limited to the Canal itself, and the temperature became rather high immediately outside the Canal.

3) In both the River and the Canal, the difference between the air temperature 0.3m over the water surface and that above the bridge was proportional to the water surface temperature, showing thus their cooling effects. The same is true of the relation between the air temperature 0.3m above the flood plain and the water surface temperature.

4) The water bodies' cooling effect was propagated from the water surface, subsequently through the air over the water surface, the bridge and finally to the streets. This effect was strongly influenced by the sea wind, its strength and its direction.

5) During day time, the Canal's cooling effect appeared to be dumped by the tiles of high temperature, in the park along the Canal.

6) Tama River's cooling effect on the streets exists only during day time. Carried by wind, it reached up to 600m in the streets. The Canal's effect was observed only during night time, and was limited to the park along the Canal.

7) Through the field measurements of the Shibaura canal's thermal environment, the energy balances' differences due to land uses, and the canal's cooling effect on its nearby urban area were clarified.

8) Using a 1-D model the various contributions to the energy balance were calculated. The results show that the canal's cooling effect exists only in day time, and it was about 1°C.

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HEAVY METALS IN BOVINES AND SHEEP REARED AND SLAUGHTERED IN THE WASTEWATER SPREADING FIELD OF MARRAKECH CITY (MOROCCO).

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ABSTRACT

The concentration of cadmium, copper and zinc have been determined in muscle (meat), bone, liver and kidney of bovines and sheep reared and slaughtered in the wastewater spreading field of Marrakech (Morocco) between 1988 and 1990. The arithmimetic mean weighted concentrations obtained related to wet-weight for muscles, bone, liver and kidneys of bovines and sheep were: (bovines : respectively for zinc, copper and cadmium: 89 ug/g; 33 ug/g and 10,3 ug/g in the kidney ; 126 ug/g, 112 ug/g and 5,1 ug/g in the liver; 129 ug/g 23 ug/g and 0,5 ug/g in the bone; 123 ug/g , 44 ug/g and 0,6 ug/g in the muscle (meat). Sheep: 84 ug/g, 26 ug/g and 7,4 ug/g in kidney; 120 ug/g , 99 ug/g and 3,6 ug/g in liver; 50 ug/g 20 ug/g and 0,4 ug/g in bone; 88 ug/g 22 ug/g 0,4 ug/g in muscle. the Obtened levels were largely higher than those of control animals. Results showed that sheep and bovines, grasing on Marrakech municipal sewage water spreading field from Marrakech (Morocco), are seriously contaminated by heavy metals, especially cadmium. Highest levels of metals are found in the liver and kidney, which are specific target organs of metal bioaccumulation.

Key words: Bovine; Sheep; Trace metals; Municipal sewage water spreading field.

INTRODUCTION

Due to a general concern about possible hazards to human health by exposure to environmental contaminations, an increasing amount of attention has been wonldwide paid during the last two decades to the presence of toxic substances in the human diet. To our knowledje none of this investigation have been applied to Morocco.

Benefits derived from using wastewaters as fertilizer have been well documented. However, there are some ecotoxicological problems linked with such use. One of the more pressing is the concern of heavy metals (Pihan et al 1987; Sedki et Pihan 1991). In this area bovines and sheep drink wastewater and their food is constituted mainly by wastewate irrigated lucerne and corn leafs. The local population consumes these plant and animal products.

Several investigation have studied the transfer of heavy metals from soil to animals either directly or via the vegetation (Medeiros et al. 1986; Koh and judson 1986). Indeed, the soil is a biochemical reactor, acting as an active filter for trace metals (Hogue et al 1984). However, it presents a danger for the vegetation and consequently for animals and humans. Other ecotoxicological studies in porks, sheep and bovines shows a direct correlation between the metal concentrations in animal food and those in animal tissues (Medeiros et al. 1986; Baxter et al 1982).

In this paper results of investigation regarding the presence of trace metals in meat, bones, liver and kidneys of bovines and sheep reared and slaughtered in the spreading field of Marrakech city (Morocco) during 1988 and 1990 are presented. The trace element levels found are compared with those reported from other countries.

MATERIAL and METHODS

The spreading field of wastewater of Marrakesh city, is enclaved in a triangular area of 3000 ha where 2000 ha are irrigated with untreated wastewaters (figure 1).

Whereas, this water is very leaded by heavy metals like Cd, Pb and Cr. The principal source of this pollution is the industry. The existing industries are mainly artisanal and food industries; these later are not increasing the content of heavy metals in wastewaters. However, the artisanal industries using chemical product compounds (fungicides, bactericides...) could also be responsable for such high content mainly for Cd and Cr. Infact, such industies are store wool and leather wich are usualy highly charged with heavy metals. The corrosion of the drinking water distribution system from the ancient city is also responsable of the lead liberation (Pihan et al 1987).

Every years (1988-1990), ten bovines and ten sheep living in the spreading field were analysed.Organs isolated from each species were the liver, the kidneys, the femur muscle and the femur bone. Samples were oven- dried (80 °c) to a constant weight and then powdred. Aliquots of about 100 mg of each powdered organs were digested with 2ml of concentrated nitric acid (HNO_3) at 200 °C for 4 hr. The volume was adjusted to 20 ml with double distilled water. Trace elements (zinc, copper and cadmium) were analysed by atomic absorption spectrophotometry (VARIAN 475 AA). Control organs were provided from a non polluted rural zone located at 20 km away from the spreading field.

RESULTS and DISCUSSION

The results obtained in this work (arithmetic mean, standard deviation and range) on the toxic and essential trace metals analysed are summarised in Table 1 (Newman and Keuls test for 5% of error).and Figures (2,3,4,5).

Within bovine tissues levels were respectively for zinc, copper and cadmium: 89

ug/g; 33 ug/g and 10,3 ug/g in the kidney ; 126 ug/g, 112 ug/g and 5,1 ug/g in the liver; 129 ug/g 23 ug/g and 0,5 ug/g in the bone; 123 ug/g , 44 ug/g and 0,6 ug/g in the muscle (meat). Sheep: 84 ug/g, 26 ug/g and 7,4 ug/g in kidney; 120 ug/g , 99 ug/g and 3,6 ug/g in liver; 50 ug/g 20 ug/g and 0,4 ug/g in bone; 88 ug/g 22 ug/g 0,4 ug/g in muscle.

According to the considered metals, the statistical study, showed an important variation of metallic levels in bovine and sheep organs. In bovines, Zn levels varied between 89 ppm (mg/kg dry weight) in the kidney and 129 ppm in the bone. A significant difference was observed between zinc kidney levels and levels encounted within other organs. In the sheep, comparisons between organs systematically established significant differences. Mean values of 50 ppm in the bone to 120 ppm in the liver.

The highest copper levels was observed in the liver for both species. The mean level in this organ was of 112 ppm in bovine and 98 ppm in sheep; a significant difference was noted between these levels and those of other organs. For kidney, means levels were 26 ppm in sheep and 33 ppm in the bovine. In the muscle and the bone, mean levels of copper were respectively 44 ppm and 23 ppm in bovine and 22 ppm and 20 ppm in sheep.

A high level of cadmium was found in kidney of both bovine and sheep. Levels for kidney and liver were respectively: 10 ppm and 5 ppm in bovine and 7,4 ppm and 3,6 ppm in sheep.

The statistical analysis showed a significant difference between the concentrations of cadmium in kidney and those encountered in other organs.

The analysis of trace element in lucerne and corn leafs, grown in the soil of this area and utilised for reared those animals , shows that such plants were surcharged by this metals (Table 2). This is caused by the surcharge of those elements in soil. This results enabled us to calculate the concentration factors (CF) defined as : the metallic concentration in the animal tissues / the concentration in the plant. It quantifies the existing transfer of a pollutant throught a food chain. As shown in table 3, concentration factors for cadmium and copper respectively in kidney and liver were greater than 1.This results showed that sheep and bovines, grasing on Marrakech municipal sewage spreading field from (Morocco), are seriously contaminated by heavy metals, especially cadmium.

As found for many heavy metals, tissue metal levels are determined mainly by the metal levels in the diet. The relation of orally administred cadmium was estimated by Vos et al (1987) to be 0.5 %, based on an experiment in which pregnant ewes and lambs were fed a diet containing cadmium up to 0.2 a 0.4 mg/kg. such estimate is considerably lower than the 5% apparent absorption calculated by Doyle et al (1974) for lambs receiving a diet containing 60 mg Cd/kg.

All the more, results showed that exposed bovines and sheep depicted significantly higher levels of metals than observed within control animals (Table 1). Thus, the pollution factor (PF= the metallic concentration in studied animal/ the metallic levels in control animals), is always higher than 1 especially for cadmium (Table 4). Calculated PF values emphasize the contamination of cattle by cadmium. Moreover, higher values of variation coefficients (CV) for cadmium are observed in all analysed organs of bovines and sheep, reflecting the heterogeneous individual levels of cadmium

The comparison with other author results showed that copper levels in the liver is similar to those noted by Baxter et al 1983 (118 ppm) and Medeiros et al 1986 (119 ppm) in cows raising in sewage sludge. As for copper, the mean level of zinc observed in the liver is lower than those noted by Friel et al 1987 (161 ppm) and Baxter and Kienholz (1983) (212 ppm) for the bovine. However, such values are superior to those reported by Underwood (1977) (50 ppm) in liver bovine living in *spreading* field.

Cadmium levels in kidney tissues was significantly higher in the exposed animals than in control. The mean levels observed are less than those found by Baxter and

Kienholz 1983 (55 ppm) in bovine and (16 ppm) in sheep feeding on contaminated vegetation. Baxter and Kienholz 1983 noted that levels arised 20 ppm in kidney of bovine raising in a sewage sludge. Van Derveen and Vreman 1986 have reported the Cd value , 12 ppm in lambs raising in sewage sludge. Those results are higher than those noted by In Friel et al 1987 (2 ppm) in bovine kidney feeding on a non polluted soil.

According to the above results, we conclude that Cd is bioaccumulated especially in the kidney, Cu in the liver and Zn as well as in kidney, liver and/or muscle. This unequal distribution within organs is related to properties differences of their respective physiological function and depends on their relative abundance of intracellular ligands able to bind metals, such as metalloproteins (Koh and Judson 1986; Kagi and Kogima 1987). Such unqual distribution is also related to heavy metal bio-availability within water, soil and vegetals.

It 's obvious that the consumption of muscle tissue, livers and kidney from sheep and bovines, living in this polluted area, is certainly contributes significantly to the average daily metals intake by man. A considerable contribution to the daily intake may arise from the consumption of organs. According to the WHO, 1979 (World Health Organisation), the weekly cadmium intake by man should not exceed 400-500 ug (Penumarthy and Oehme, 1980). For lead the joint Expert Committee of the FAO/WHO propose a to lerable daily lead intake for adults, of 430 µg. In Morocco, no legal limits yet have been estabilshed for any heavy metal levels in the meat and organs of bovines ans sheep.

CONCLUSION

In ralation to the health of man te concentrations of cadmium, copper and zinc found in muscle, liver and kidneys of bovines and sheep grasing on Marrakech municipal sewage spreadind field from (Morocco) are very high. The levels of cadmium in muscle and edible organs of cattle determined in this study were considerably higher than those reported for animals from other countries.

Dramatically, high levels of cadmium were encountered resulting from bio-accumulation (CF > 1) and bio-amplification (PF >1) processes.Highest levels of metals are found in the liver and kidney, which are specific target organs of metal bioaccumulation.

As cadmium is known to be a highly toxic compound to wich chronic exposure results in severe diseases or even death, it is an urgently needed to initiate an extensive epidemiologic study of people consumming these products (vegetables and meat) originating from this area.

ACKNOWIEDGEMENTS

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Table 1: Means concentration of heavy metals in tissus of Bovines and Sheep (mg/kg, Dry weight).
Tableau 1: Concentrations des métaux lourds dans les tissus des bovins et des ovins (mg/kg, poids sec).

		KIDNEY				LIVER				BONE				MUSCLE			
		B	S	CB	CS	B	S	CB	CS	B	S	CB	CS	B	S	CB	CS
Zn	M	89	84,2	39,8	32,5	126	120	59,7	47,9	129	50,4	75,7	41,4	123	87,9	45,8	38,6
	SD	13,6	13,4	3,6	3,6	22,2	18,6	7,1	7,2	19,3	9	5,4	4,9	21,4	21	5,9	3,7
	VC	15,2	15,9	9	11	17,6	15,4	11,9	15	14,9	17,8	7,1	11,8	17,3	23,9	12,8	9,58
	Min	66	63	36,2	28,9	95	104	52,6	40,7	96	40	70,3	36,5	89	51	39,9	34,9
	Max	112	111	43,4	36,1	161	159	66,9	55,1	155	66	81,1	46,4	154	117	51,7	42,4
Cu	M	33,2	25,8	15,3	9,9	112	98,7	45	44,4	23,3	20	16,2	14,2	44,3	22	12,2	10,8
	SD	7	5,4	1,2	1,3	22,9	22,5	5,5	7,6	6,3	5,2	2,6	1,8	11,2	5,2	1,3	2,3
	VC	21	20,9	7,8	13,1	20,4	22,8	12,2	17,1	27	26	16	12,6	25,2	23,6	10,6	21,3
	Min	23	17,9	14,1	8,6	76	59	39,5	36,8	16,9	14	13,5	12,4	26,8	15,2	10,9	8,5
	Max	48	36	16,5	11,2	156	134	50,5	52,1	36,2	31,5	18,8	16,1	60	31,7	13,5	13,1
Cd	M	10,3	7,4	2,2	1,35	5,1	3,6	1,67	1,4	0,47	0,4	0,2	0,1	0,6	0,4	0,2	0,1
	SD	2,5	1,2	0,85	0,25	1,4	1,2	1,07	1,1	0,02	0,2	0,02	-	0,2	0,2	0,07	-
	VC	24,2	16,2	38,6	18,5	27,4	33,3	64	78	5,2	50	10	-	33,3	50	35	-
	Min	5,7	4,8	1,4	1,1	2,9	2,1	0,6	0,3	0,45	0,2	0,2	-	0,25	0,15	0,15	-
	Max	13,5	9,1	3,1	1,6	7,1	6,1	2,75	2,5	0,5	0,6	0,25	-	1	0,85	0,3	-

M : Mean (n = 10)
CV : Variation coefficient
Min : minimum
Max : maximum
SD : standar déviation

B : bovine
S : Sheep
CB : control bovine
CS : control sheep

Table 2 : Values of heavy metals in wastewater, soil and plant.

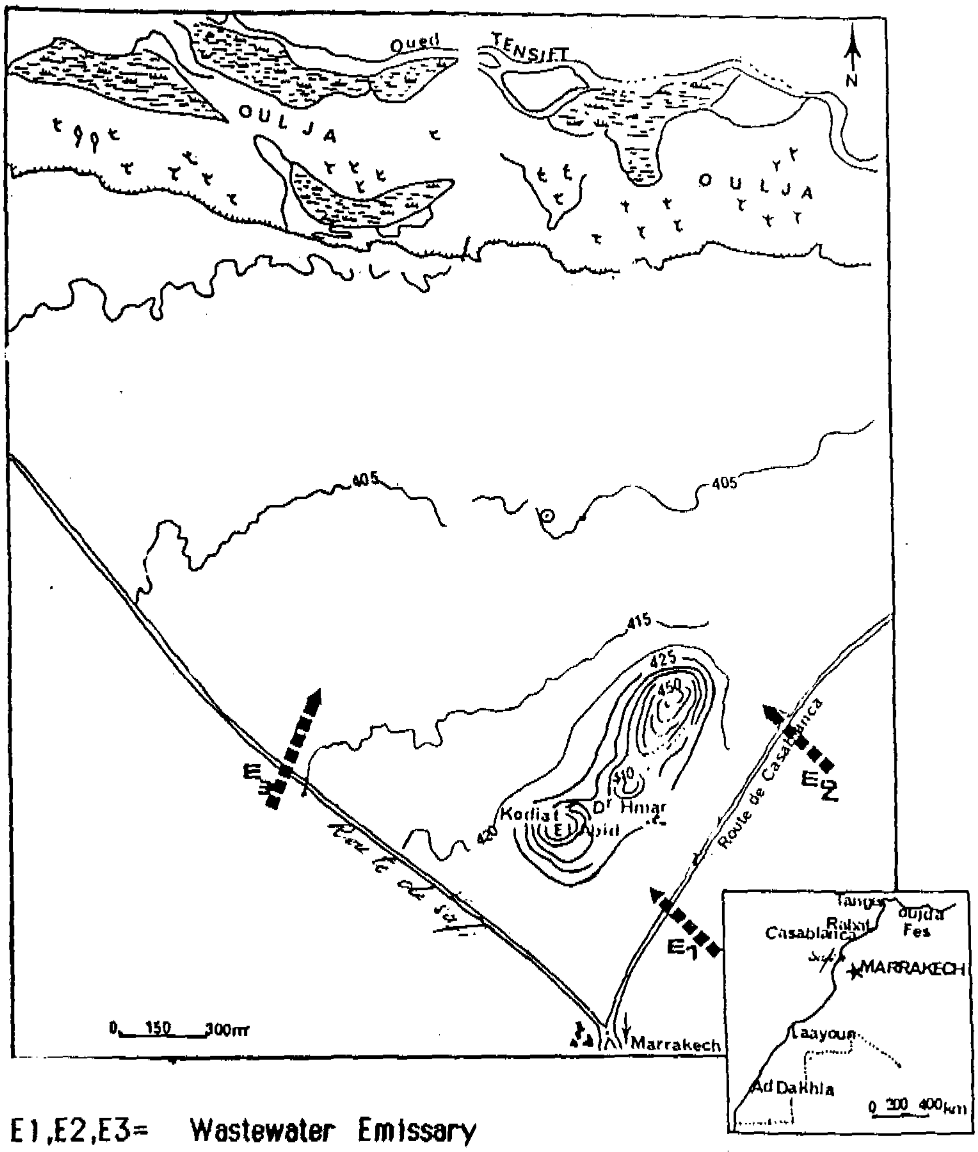
	Wastewater (mg/l)	Soil mg/kg	Lucerne mg/kg	Corn leafs mg/kg
Zn	4.5 ±1.5	450 ± 75	250 ± 45	380 ± 66
Cu	0.4 ± 0.2	120 ± 22	44 ± 12	65 ± 14
Cd	0.03 ±0.01	5.5 ± 2.5	1.4 ± 1.1	2.2 ± 1,3

Table 3 : Values of concentration factor

		Kidney	Liver	Bone	Muscle
Zn	Bovine	0.3	0.5	0.5	0.4
	Sheep	0.3	0.4	0.2	0.3
Cu	Bovine	0.8	2.8	0.5	1.1
	Sheep	0.6	2.5	0.5	0.5
Cd	Bovine	3.3	0.9	0.1	0.1
	Sheep	1.5	0.9	0.08	0.08

Table 4 : Values of pollution Factors

		Kidney	Liver	Bone	Muscle
Zn	Bovine	2.2	2.1	1.7	2.6
	Sheep	2.6	2.5	1.2	2.2
Cu	Bovine	2.1	2.4	1.4	3.6
	Sheep	2.6	2.2	1.4	2.0
Cd	Bovine	4.6	3.0	2.3	3.0
	Sheep	5.4	2.5	4.0	4.0



E1,E2,E3= Wastewater Emissary

Figure 1: Municipal wastewaters spreading field of Marrakech.

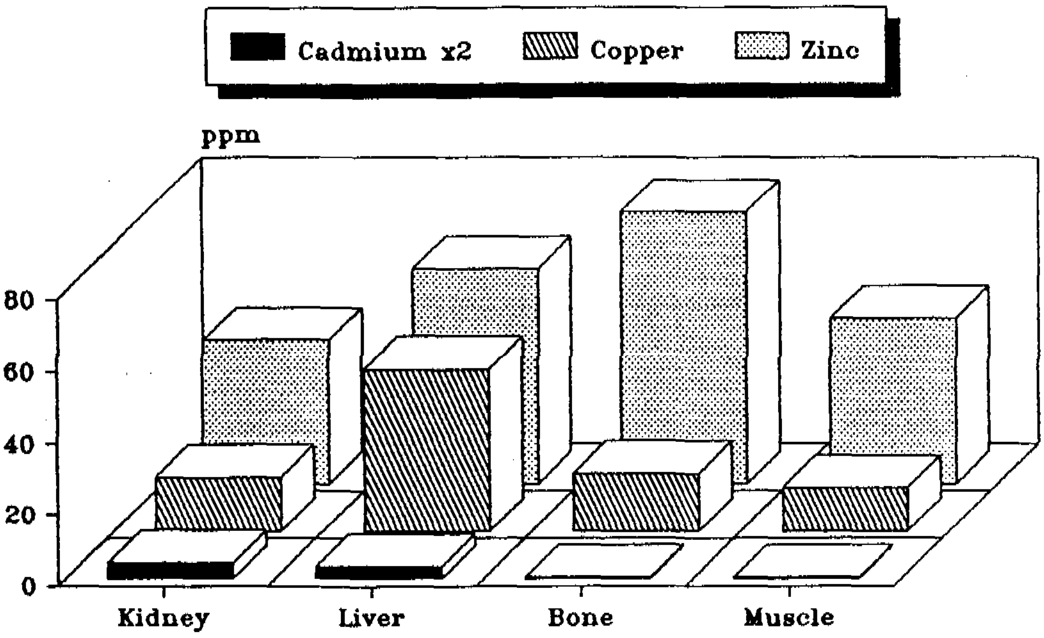
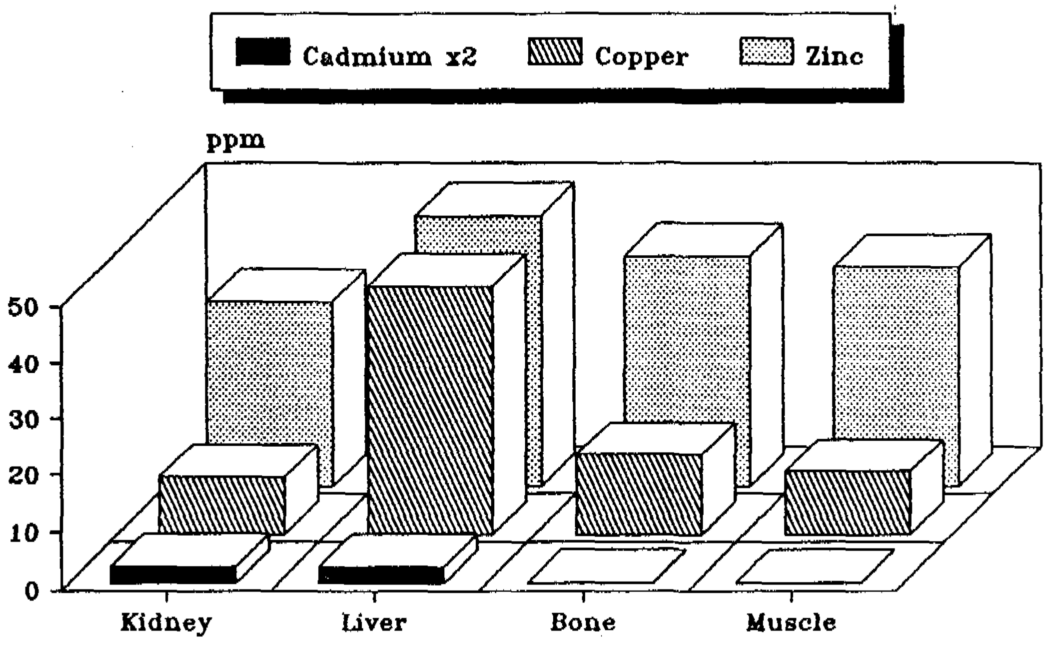


Figure 2: Mean concentrations of trace elements in tissues of control bovine (mg/kg, Dry weight).



Fgure 3: Mean concentrations of trace elements in tissues of control sheep (mg/kg, dry weight).

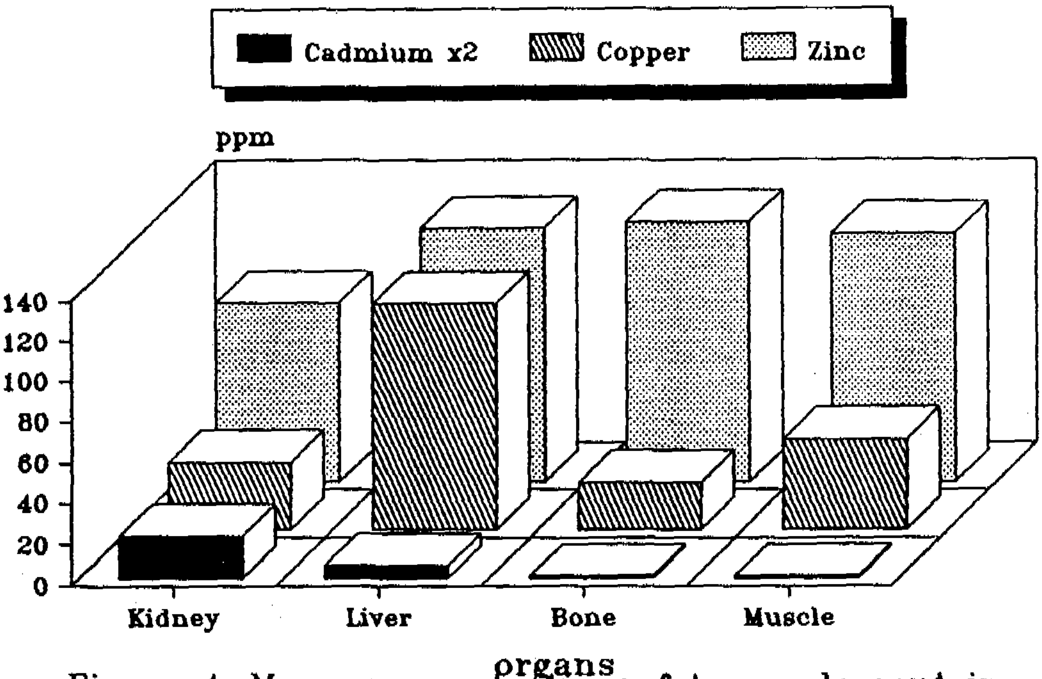


Figure 4: Mean concentrations of trace element in tissues of exposed bovine (mg/kg, Dry weight).

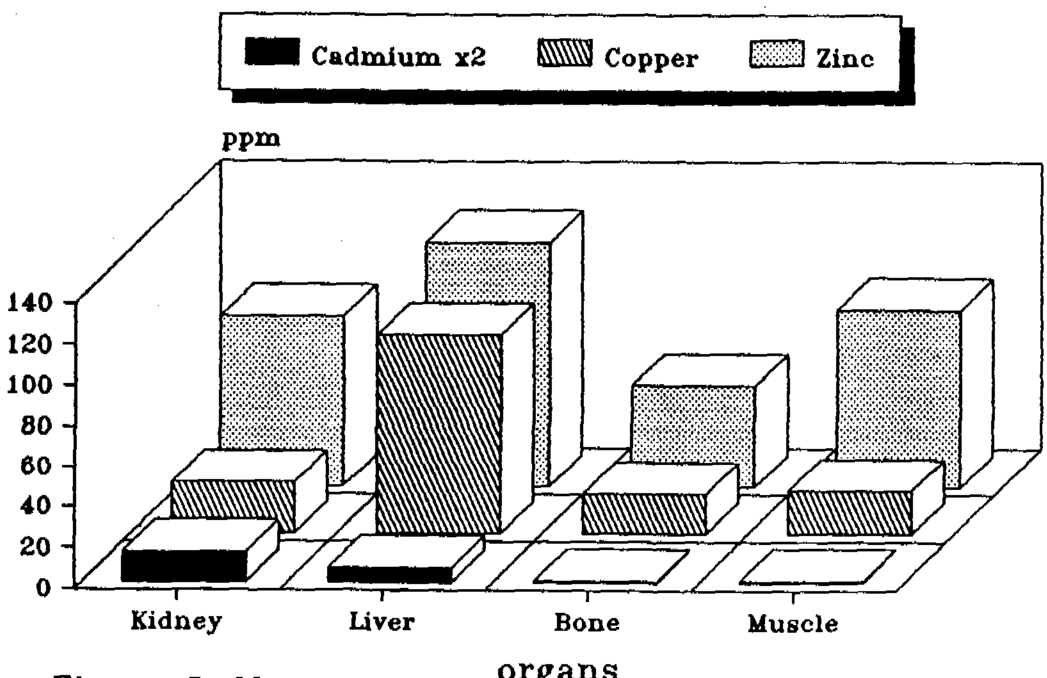


Figure 5: Mean concentrations of trace elements in tissues of exposed sheep (mg/kg, Dry weight).

QUATERNARY SEDIMENTS AND THE HYDROGEOLOGICAL CONDITIONS OF WADI FEIRAN SOUTH SINAI-EGYPT

BY

BAHAY ISSAWI[1] AND ELSAYED ZAGHLOUL[2]

ABSTRACT

The lacustrine sediments in Wadi Feiran and adjoining areas points to a wetter phase which dominated over South Sinai during the time span from 60,000 years B.P. to 12,000 years B.P. Since 12,000 years gradual aridity caused a cessation of fresh water deposits in three local basins along the course of Wadis Akhdar, El-Sheikh, Solaf and Feiran. Degradation took place since then leaving handing terraces and step like features.

The lacustrine sediments carry fresh water at their submerged parts below the present wadi level. Together with the fissured precambrian rocks, the lacustrine sediments make a unique hydrogeologic province rarely found in other parts of Sinai.

RÉSUMÉ

Les sediments de lacustre a' Wadi Feiran et les surfaces avoisinantes marquent une phase pluvieuse qui dominait sur toute I' etendue du Nord Sinai. C'etait a' l'intervall enter l'anne'e 60,000 A.C. jusqu'a l'anne'e 12,000.

Depuls 12,000 ans une aridite graduelle a cause' l'arret des de

l'eau douce dans trois bassins locaux tout le long de cours du WADI KHDER, EL SHEIKH SOLAF et FEIRAN. Une de'gradation a eu lieu depuis ce temps en laissant des terrasses caracterisees par degres.

Les premiers sediments de lacustre d'eau dont quelques parties ont subme'rge se'diments de lacustre douce dont quelques parties ont subme'rge au dessous du inveau actuel de WADI avec les roches crevasse'es du PRECAMBRINE ont cree une province hydroge'ologiqu qui est raement trouvee dans d'auters parties a' SINAi.

INTRODUCTION

Wadi Feiran and its main tributaries, is the principle western drainage system of southern Sinai massif. The catchment area encompasses about 1800 Km^2 divided into at least three main basins (Fig.1). The lower basin is located downstream west of Feiran Oasis, the central basin lies inbetween Feiran and Tarfat including Feiran itself where as an upper basin was developed at the junction of the three major wadis namely Akhder, Solaf and El-Sheikh join near Tarfat Oasis forming the main trunk. At wadi El-Sheikh, Wadi Solaf as well as in Wadi Feiran, well sorted, fine-grained pleistocene sediments including archeological remains, are present. In places, there are as many as 50 m of lake deposits with strata of marl, sand and silt. Digging at Wadi El-Sheikh near Watia pass reveals another 70 m of the same deposits though with much igneous pebbles and gravels increasing with depth i.e near the basement rocks.

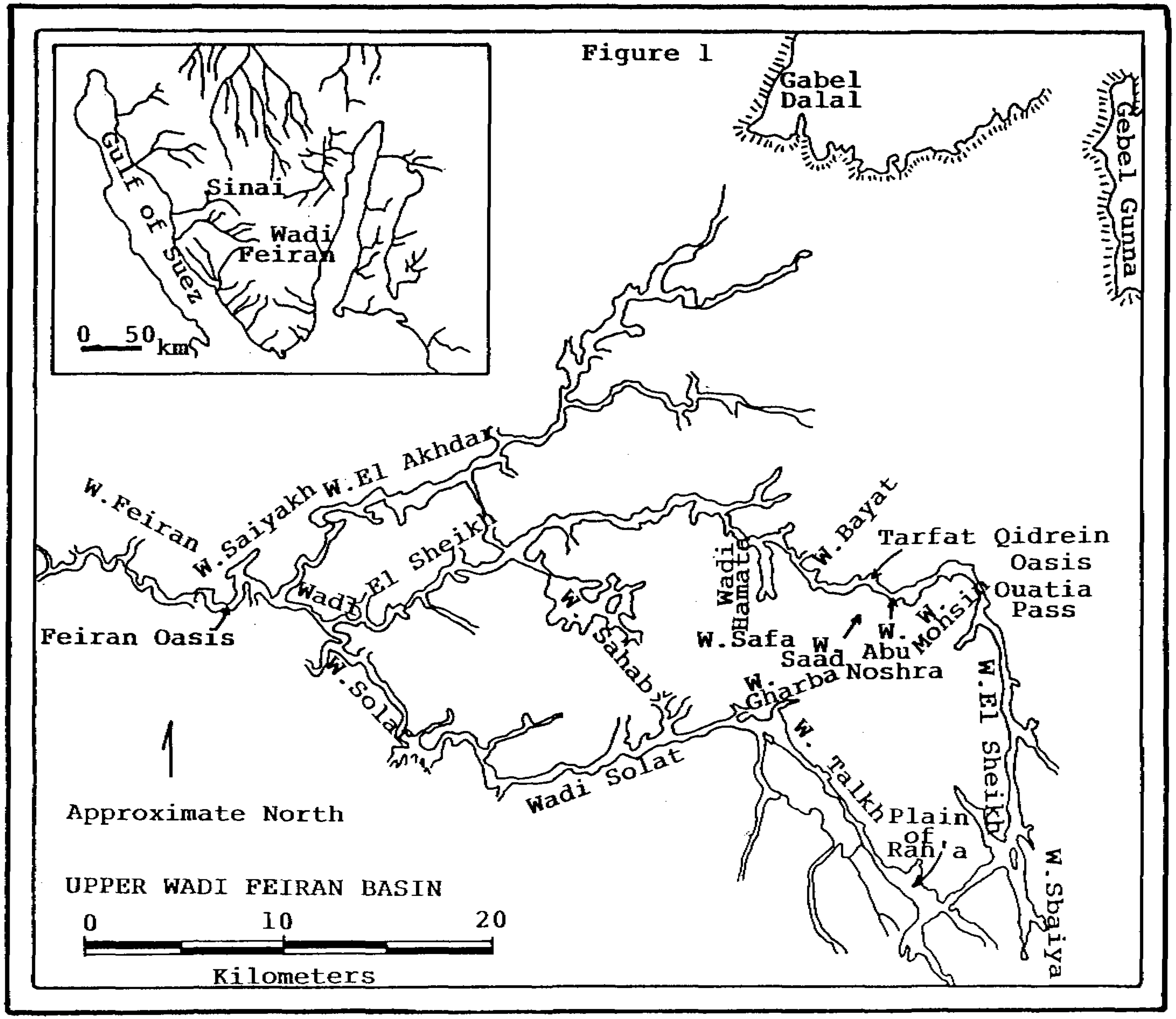


Figure 1
Gabel Dalal
Gebel Gunna
Sinai
Gulf of Suez
Wadi Feiran
0 50 km
W. Feiran
W. Saiyakh
W. El Akhdar
Wadi El Sheikh
Feiran Oasis
W. Solat
W. Sahab
Wadi Hamate
W. Safa
W. Saad
W. Abu Noshra
W. Mohsin
W. Bayat
Tarfat Qidrein Oasis
Ouatia Pass
W. Gharba
W. El Sheikh
W. Talkh
Plain of Rah'a
W. Sbaiya
Wadi Solat
Approximate North
UPPER WADI FEIRAN BASIN
0 10 20
Kilometers

The occurrence of lack deposits at Tarfat and Feiran Oases has been noted more than 100 years (Walter, 1888, Baron, 1907; De Martonne, 1947 and Awad, 1951, 1953). These deposits are Known in the geological literature as " Feiran beds" and has been considered by many authors as of lacustrine origin.

The Wadi Feiran and its two main affluents Wadis El-Sheikh and Akhdar drain a considerable part of southern Sinai which is covered by Precambrian rocks except near Wadi Feiran mouth where Upper Cretaceous and Paleogene sediments croput. The feeders of Wadi El-Sheikh get their waters from Gebel Moussa (2285m), Gebel St. Katherine (2639m) and also from other mountains in the nearby of these two mountains. About 4 Km up-wadi from Tarfat Oasis, Wadi El-Sheikh emerges from Watia pass, a deep (350m) narrow gorge traversing the ridge of Gebel El-Banat (1583m). Tarfat Oasis is situated along the north west piedmont of this range, 650 m below its summit. Wadi Abu Nosra is one of a few small basins along the northern flank of Gebel El-banat that funnel runoff and sediment into Wadi El-Sheikh.

Feiran Oasis is situated 30 Km west of Tarfat along Wadi Feiran itself. The Oasis rises 630 m a.s.l.i.e 480 m below Trafat. Wadi Feiran meanders west of the Oasis into acute loops before it fans near the coast of the Gulf of Suez. The slop of Wadi Feiran from the Oasis to the sea is nearly 1:70, whereas the gradient of Wadi El-Sheikh between Gebel El-Banat and its junction with Wadi Feiran is 1:100. On the other hand, the Wadi Feiran slopes 1:115 in the 15 Km stretch of the middle basin around Feiran Oasis.

PREVIOUS WORK

Fresh water lake deposits were described by Barron (1907) in the environs of Feiran and Tarfat. Extensive deposits, about 30m thick, were described from the areas of Tarfat and Feiran and extending laterally into the mouth of many wadis in the nearby of these two oases.

The first detailed description of the lake beds in the area was made by Awad (1951). He mapped and described lacustrine sediments as occurring discontinuously for more than 30 km along the course of Wadi El-Sheikh, from Feiran at Watia Pass, and in the head waters of Wadi Solaf. The deposits consists of gravel within fine sand, in places showing torrential stratification, and stratified clay and whitish fine sediments. These beds have been dissected and may form lacustrine terraces and in places they are buried by more recent colluvial deposits. Awad concluded that one, large, deep lake could not have formed, rather local condition promoted impoundment. Barriers across the course of the main wadi were formed by alluvial fans produced by grand floods of tributary valleys, often opposite one another, debouching into the thalweg of the principal valley.

Issar and Eckstein (1969) published the first description of sections through the beds; 20m near Feiran Oases and 20 m to a 12 m sections near Tarfat. The beds are varied marl, silt, clay and fine sand interlayered with marl including fossil roots and reeds of fresh water flora. Occasional layers of coarse sand and/or gravel, usually less than 0.5 thick, are found within the sections. The authors conclude that shallow lakes developed at many different levels during the deposition of the beds, impounded by dikes which formed barriers across the major wadi system and also acted as aquiclude. Coarse fluviatile sediments which intercalate with and flank the lake deposits denote periods of more precipitation during the generally more humid conditions that are inferred to have prevailed in the late Plio-Pleistocene.

Nir (1970) differentiated in the Feiran beds between lacustrine, torrential, talus and alluvial fans modes of deposition. At Tarfat the deposits attain a maximum thickness of 80m. Nir also suggested that the high calcium carbonate content in the lacustrine silt fraction is aeolion, derived by northeast winds from the Tih escarpment a short distance to the north. Nir proposed that the Feiran beds accumulated at Feiran and Tarfat, not because of barricades of dikes or alluvial fans in the major wadis but because of regional tilting since the Tertiary.

Gladfelter (1988) believed that lacustrine facies occurred upstream from bedrock constructions of the Feiran - El-Sheikh valley as at the Tarfat and Feiran Oases. The wider and more open areas in the wadis floors prompted general alluviation rather than poinding.

Gladfelter (1990) dealt with the geomorphic setting of Upper Plaeolithic sites in Wadi El-Sheikh showing that a protracted phase of aggradation without evidence for episodes of cutting and filling occurred in the drainage of wadi El-Sheikh between about 65000 and 12000 B.P. Water conditions favouring the formation of marls are explained by local, geomorphic factor including the orographic influence of nearby mountains. A major phase of down-cutting initiated at the end of the Pleistocene and beginning of the Holocene is the only climatically forced gradational change seen in the geomorphic record.

GEOLOGIC SETTING

The lake deposits in Wadi Feiran-Wadi El-Sheikh described in the literature are one facies of a thick, Late Pleistocene aggradation that occurred through wadi system in the igneous and metamorphic province of Souther Sinai. Remnant of these deposits still can be seen today, sometimes as well defined, discontinuous terraces throughout the Feiran and El-Sheikh - Solaf - Akhdar system and in many other wadis in the south Sinai area. Some of the coarse sediments of these deposits are pasted against the bedrock walls high above the floor of the wadi. The settings to a much thicker aggradation of lake or alluvium beds within the wadi system when the Quaternary series developed along the many intricate drainage basins in the area (Fig. 2). In lower order tributaries to the main wadi courses, the Late Pleistocene valley - fill survives as degraded terraces far up into basin - heads, frequently more than 60 m above the modern floor of Wadi El-Sheikh for example.

The Quaternary deposits recognized different types of sedimentation : colluvial, lacustrine and fluviatile. It had been observed (Nir, 1970) that laterally there are textural gradations of the sediments so that, for example, a sedimentary unit is very coarse where it abuts a bedrock slope and becomes finer toward the center of the valley. Reference also has been made to torrential gravels that denote low frequency, high discharge event not unlike these of contemporary floods (Nir, 1970). These descriptions imply that major changes in sedimentary texture indicate intervals of significant hydrologic change.

The following section measured and described in Wadi Abu Nosra, a tributary of Wadi El-Sheikh, represents the sequence of Quaternary sediments in South Sinai area. The importance of these sediments is that they are fresh water bearing and their setting above the basement complex is a unique model for the many water provinces in Sinai.

Top: -Sandy silt interbedded with coarse sands and gravels including fine carbonate bands, roots casts at top which is crudely stratified grussic granular sand with pebbles and coarse gravels of limestone and flint .... 15.8 m

- Massive sandy silt with a few root casts and faint, diffuse ferric mottling, including many discontinuous seams of well sorted red silty sands and white carbonate, marl at top.................................. 4.0 m

-Sandy silt, indurated, with marl intercalations . 1.2 m

- Ferruginous sandy silt with thin discontinuous seams of calcareous silt and few root casts, marl band (40 cm) at top .... 2.0 m

- Massive sandy silt with roots casts and slight ferric mottling, blocky structure, where freshly exposed, carbonate intercalation is common near base, black organic veinlets associated with clay band.........4.0 m

- Calcareous sandy silt with slight ferric mottling, root casts are common, marl band at the middle 40 - 50 cm thick, grussic granular sand near top and bottom ...2.5m

- Interbedded sands and silts with occasional seams of clay, marl band 20 cm thick near middle including molluscs.. 1.8 m

Base - Interbedded sandy silt and silty sand, including marl bands and carbonate concretions, root casts are common indicating stabilized vegetated surface........... 1.3 m

The basement rocks nearly encircle the above mentioned section which might cover spacious to elongate areas depending on the exhumed weathered surface of the basement.

At Tarfat, a thin band of travertine has been dated 65000 B.P. by H. Schwartz using Thorium/Uranium (Gladfelter, 1990). The travertine is just two meters above the present wadi floor and unbroken sequence of sediments occur above it. The time of aggradation certainly had begun appreciably earlier if the body of sediments that comprise the current floor of the wadi beneath the dated exposure is part of this aggradation phase. The aggradation during the late pleistocene terminated some time after 12000 B.P. (Gladfelter, 1990) which is the youngest date obtained from deposits at top of the sedimentary column. So, through out a period of more than 50000 years contemporaneous with the last glacial, valleys in the Feiran- St. Katherin stretch and also in the adjacent areas were infield with sediments varying from fine to coarse and very coarse materials. Since 12000 years B.P. and up to the present time sediments are continuously flushed to the sea in the west and which is more important, degradation resulted in the dissection of the thick lacustrine sediments into several terraces overhanging each other. In other words the pleistocene terraces in Wadi Feiran and adjoining areas are erosional features rather than rising aggraded steps as advocated by Awad (1953). The presence of marl bands in the sequence points to a stagnant stability phase within the continuous overall aggradation episode.

POUNDING CONDITIONS

The presence of thick Pleistocene sediments in Southern Sinai, Feiran area, has triggered many thoughts on the conditions which led to the location and formation of these sediments. Both Awad (1951) and Issar and Eckstein (1968) believe that barriers across the major wadi system led to pounding. Gladfelter (1988, 1990) though postulates that the water was not impounded or dammed behind obstructions in the valley bottom such as alluvial fans (Awad , 1953) or dikes (Issar and Eckstein, 1969), yet he mentioned "patterns of sedimentation in the valley bottom of Wadi El-Sheikh were constrained by the configuration of the bedrock surface" (Gladfelter 1988, P. 45). The environmental conditions that favoured a positive hydrologic budget can not be effective, as far the writers can see, unless some how the water should be kept or trapped from flowing into the sea. The statement by Gladfelter (1988, P. 45) that the net aggradation at Tarfat with paludal facies related to the size and form the basin upstream compared to the size of the valley constriction, implies that a constriction is an important factor in determining the physical status of the factors which led to pounding.

The geographic location of the lacustrine sediments at the contact between the sedimentary terrain of Gebel Dalal (Egma - Tih Plateaux) to the north and the basement rocks of St. Katherine and impressive mountains of south Sinai has a great impact on the formation of ponds in the Wadi Feiran area. The valleys descending from Egma - Tih complex e.g. Wadi Akhder, and flowing to the south meet the other wadis draining the basement complex e.g. Solaf and El-Sheikh near the junction with Wadi Feiran. The fabulous amount of waters brought by these wadis are trapped in the area because of the prescence of at least two main constraints not necessarily dykes, but the main rock itself forming an intracratonic basin within the basement mountains (Fig.2). The gradient at Tarfat is 1:100 whereas at Feiran the slope is 1:115. On the other hand west of Feiran the slop is 1: 70. The gentle slopes at both Tarfat and Feiran basines the constrictions in both areas make a suitable setting for bonding. Certainly flowing from the easterly basin, Tarfat, to middle basin, Feiran, occurred and a similar model happened west of Feiran towards the sea. the filling of the two main ponds and their intermittent pouring of waters to the west help in abrading and lowering the constrictions during the time of filling and emptying. Contrary to Gladfelter (1988, 1990) assumption about the short time to break the constrictions since 12000 years B.P. it is believed that the wearing away of these obstacles took place since the first initiation of the ponds. It

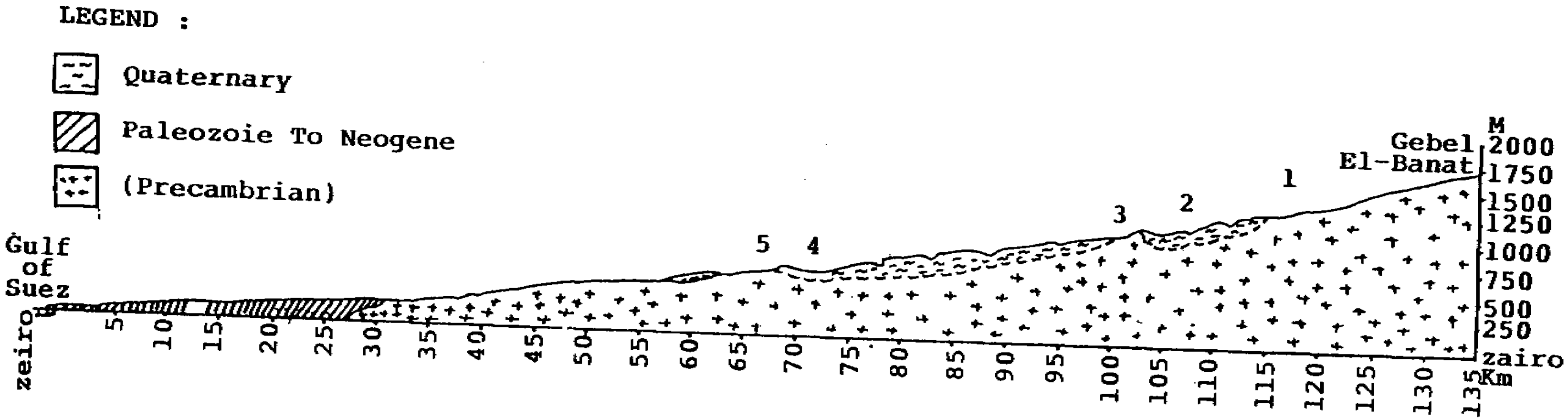


Fig.(2) Cross Section Between Gebel el Banat and Gulf of Suez.

might be possible that damming was helped by sediments from the pond itself superimposed on the basement rocks at the area of the present narrow necks in the wadis courses.

HYDROGEOLOGIC SETTING

Coarse gravel mark the initial deposition of the Pleistocene beds in certain and many places in the Wadi Feiran area. The gravels reflect the local delivery of sediments from the colluvial apron of the nearby gebels. The increased discharge requisite to transport these gravel was derived from the slops of the gebels where as the orographic effect intensified the runoff even from moderate precipitation events.

The Pleistocene section unconformable overlies highly dissected basement rocks. Both lithotopes carry quiet a good deal of potable water judging by the number of people living in the area and the relatively sizable plantations. However, comparison of paleo - conditions to the contemporary landscape must take into account the fact that the latter is not pristine; it has been denuded by overgrazing browsing and increased population pressure. The term desertic as applied to southern Sinai can, then, be misleading even though it is situated within the latitude of Arabo - Saharn desertic belt. Statistically reliable data on local precipitation are not available, reference to amount of annual precipitation range from 50 mm (Cohen and Goldbery, 1982) to 200 mm (Nir, 1970). Actual measurements of unknown duration at St.

Katherine cited by Bein and michaeli (1972), record 60 mm of annual precipitation occurring from October May. Barron (1907) reported that for this same period in 1898 - 1899 it rained on 20 days and on eight of them the precipitation was quite heavy. He stated that wind direction generally is north west but it is the winds from the south west that bring rain. On March 24 - 25, 1986, it rained steadily all night at St. Katherine from about 11 P.M until 6 A.M. (Phillips, J., Personnel Communication). A sustained precipitation event such as this is marked contrast to the conventional notion that desert storms are brief, intense and produce flashy or torrential runoff. An 80 minute storm did occur later that season (April, 25) however it did not result in turbulent runoff within the wadis. It is clear, however, that mountainous southern Sinai is today " wetter" than are the surrounding low-lands, receiving an the order of five times more precipitation than the nearby coastal plain 50 Km to south west (comparison with El-Tor). The existence of ponds during Late Pleistocene must mean that there was a significantly improved water balance, indeed a surplus of precipitation over evaporation to account for standing bodies of fresh water on the surface. This contrast between the recent past and today points to a gradual aridity over the area since 12000 B.P. and the word " wetter" just mentioned is certainly relative.

To sum up the lacustrine deposit at both Tarfat and Feiran Oases carry fossil water especially at the contact with the underlying fissured basement rocks (Fig.3). The water is confined in a clastic section in the two basins; Upper or Tarfat and the middle or Feiran, whereas in the lower basin the water naves of the sea. The water in the upper and middle basins is limited owing to the relatively limited size of these two basins and to the thin section carrying the water as well . The lower basin is much bigger in size and the aquifers are much more thick than the other two easterly basins. More than one aquifer is met in the lower basin, the Upper Pleistocene aquifer and the lower clastic probably Lower Cretaceous aquifer. The dimensions of these basins and their water content need further study.

Generally in Wadi Feiran the main groundwater aquifers are the jointed and cracked pre-cambrine crystalline rocks where many springs and shallow dug wells are located, and the quaternary alluvium deposits in the basinal areas (Fig. 3).
The origin of the water is meteoric and the salinity of the total dissolved solids (TDS) ranges from 1200 to 1500 ppm
The potentiometric water level rangers from 45 to 58 m.

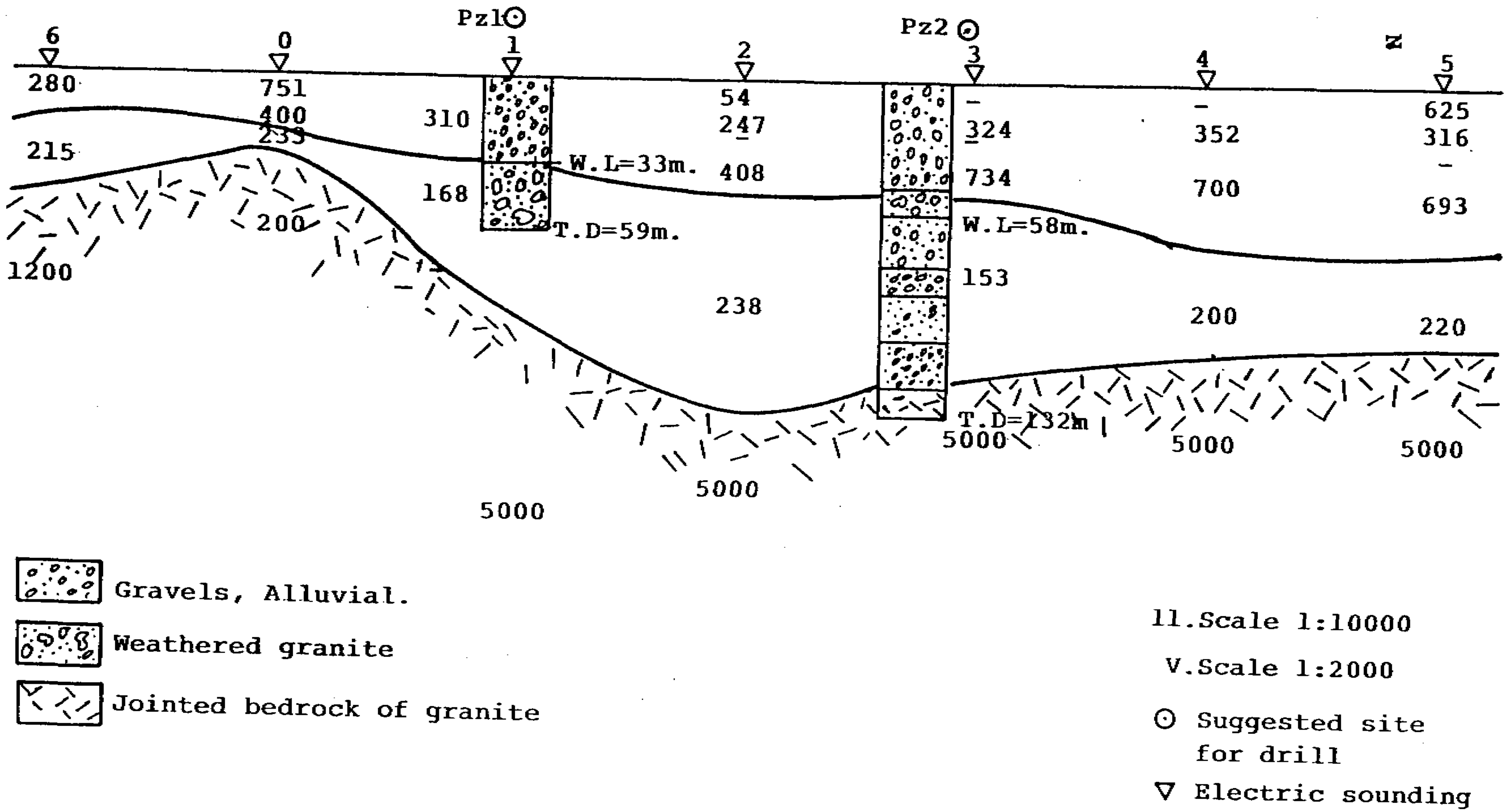


Fig.(3) Geoelectric Section along Wadi EL-Sheikh.

(After: EL-Sorad, 1992).

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EXPERTISE IN SATISFYING WATER DEMANDS IN AUSTRALIAN PREHISTORY

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ABSTRACT

Australians have been living on the Australian continent since at least 40,000 years ago. May be even some thousands of years before. Many significant environmental changes in climate, flora and fauna have occurred during that period of human occupation.
Satisfying water demands has been a constant concern. Due to the fairly consistent low precipitation rate throughout the continent, along the coast as well as inland, to the very arid, dry desert area, it was necessary to search, find and protect natural occurrence of water and water resources. Water retention in naturally occurring rock pools was extensively exploited and carefully guarded.
An important source of water, particularly in the arid inland were so called native wells. Numerous such wells exist throughout the vast continent. Some interesting native wells, formerly also Aboriginal occupation sites, have been traced in the Simpson Desert.
In numerous locations within the continent fresh water fish and eel trap systems were built to satisfy food requirements of the people.
Coastal fish traps are in existence along most for the suitable seaboard locations, from the east coast to the west. The construction of the hydraulic structures was carried out with simple tools and limited materials.
All these hydraulic structures built to satisfy water and food requirements of the people could be compared reasonably favourably with the impressive hydraulic structures of Ancient Egypt and European antiquity.

RÉSUMÉ

Les australiens habitent le continent australien depuis au moins 40 000 ans. Peut-être même quelques milliers d'années avant cela. Tout au long de cette période de peuplement humain, l'environnement a connu de nombreux changements importants du point de vue du climat, de la flore et de la faune.
La satisfaction des besoins en eau a été un souci constant. En raison des faibles précipitations qui sont pratiquement une constante sur tout le continent australien, de la côte aux zones particulièrement arides et désertiques de l'intérieur, il a été nécessaire de chercher, trouver, puis proteger les ressources en eau.
Recueillir et conserver l'eau des petites mares qui se formaient naturellement au milieu des rochers était une pratique très répandue, et on les surveillait de près.
Une source importante d'approvisionnement en eau, notamment dans les zones arides, étaient ce qu'on appelle aujourd'hui les puits indigènes. De tels puits existent en grand nombre à travers le vaste continent. Des puits indigènes intéressants, qui furent autrefois des sites d'habitation aborigènes, ont été retrouvées dans le désert de Simpson.
En de nombreux endroits a l'intérieur du continent on a fabriqué des systemes de piège poissons et anguilles d'eau douce pour répondre aux besoins en nourriture des habitants.
On trouve des pièges à poissons d'eau peu profonde dans pratiquement tous les lieux qui s'y prêtent le long des côtes, de l'est à l'ouest.
Ces systèmes hydrauliques étaient construits à l'aide d'outils simples et tres peu de matériaux.
On pourrait comparer de manière assez avantageuse l'ensemble de ces systèmes hydrauliques réalisés pour satisfaire les besoins en nourriture des populations aux structures hydrauliques impressionantes de l'Antiquité égyptienne et européene.

INTRODUCTION

Human occupation of the Australian continent has been established to go back to at least 40 000 years. However data indicate that the first arrival of people, in Australia was most significant as the earliest evidence of modern human behaviour and dates back to about 53 000 years B.P. [Davidson & Noble, 1992].
Variation in global temperature had momentous influences on sea levels. When the glacial maximum occurred at about 18 000 BP the sea levels around the Australian continent were about 150 metres below the present and the continent extended far beyond its present shores. Another earlier set of glacial maxima occurred at round about 50 000 BP a date established by geomorphology field studies [Chappell, personal communication 1994].

Significant environmental changes occurred within the extensive time span, from before the arrival of people to the present day. There were remarkable changes in climate effecting precipitation, temperature, air movement and with it evaporation.
Although the original inhabitants, the Australian Aborigines, did not consider themselves as one people, their activity throughout the continent, within different language groups, did possess a cultural unity. They did not claim land ownership but considered that they were owned by the land. They have a close relationship to the land and the environment, a remarkably deep knowledge of the country, including its water resources at ground level and below the land surface.

The concern with water by the Aboriginal people is found to be consistently significant, independent of wether the groups were living in close proximity to the ocean shore, in areas where fresh water was available in creeks or rivers, or in dry inland areas, sometimes extending into the desert. From the records of the various communities, which have been gathered over time, there is evidence of a general ability to deal with their environment, which we might now term engineering expertise. They exploited the resources as they found them throughout the country with great skill though neither metals nor ceramics were ever developed.
The specific expertise in satisfying human needs for water and exploiting water will be presented in a few case studies selected randomly from quite a number of examples which are in existence. As water is most essential for life existence illustrations of expertise in knowledge of location, storage and protection of water will be dealt with first.

1. ROCK POOLS AND NATIVE WELLS

1.1 Rock Pools in the Sydney Area

Rock pools are geological features which have in prehistory times been used as a means of storing water. It has also been reported that they were sometimes used to heat water for cooking food. In some situations rock holes have been extended by pounding the sides and the bottom to increase their capacity. They could also be made more effective by the provision of special guiding grooves leading the natural run-off into the holding pools [Magarey, 1894].
The predominant rocks in the area of Sydney are triassic fresh water sediments, i.e. Hawkesbury Sandstone and Wianamatta Shale. The former comprises of bonded coarse grained quartz sand and is prone to the development of rock holes where the rock is slightly weaker. Many, mostly small rock pools can be found in the Sydney Area.

1.2 Kelly's Bush Rock Pool, Sydney

An interesting example of a rock pool exists in the Sydney municipality of Hunter's Hill. That local government area is located on a peninsula between the Parramatta River and Lane Cove River. Both the Parramatta and the Lane Cove River are drowned rivers for a long distance upstream, well past Hunter's Hill.
Within this municipality Kelly's Bush, a small public reserve area of about 4.8 hectares has been retained.
Roughly in the centre of this reserve, about 30 meters from the coast of the Parramatta River is a fairly large rock platform about 11 meters across by 5 meters wide. Almost in the middle of the platform is a rock pool about 3 meters long and possibly 1.2 meters deep.

The importance of the rock pool is that, there are no reasonably permanent fresh water streams on the whole of the peninsula, although there may have been some small springs. Thus the rock pool would have been an important facility for storing water in the area, at the time of prehistoric usage of the land [Attenbrow, 1988].
Along the waters edge of the Parramatta River, about 70 meters south of the rock pool there are rock shelters and Aboriginal middens.

1.3 Puritjarra Rock Shelter and Rock Hole, Central Australia

In almost exactly the centre of Australia, in an extremely arid area, is the Puritjarra Rock Hole and close by the huge Puritjarra Rock Shelter.
Rainfall in this area is very low, averaging less than 350 mm a year. By comparison Average Annual Rainfall in Sydney, Australia is 1 225 mm, but in Cairo it is only 29 mm. During the last glacial episode the conditions in the area, were even more arid and colder than at present.
This country around the Cleland Hills covers about 8 000 square kilometre of dry land. The only permanent water is at the Puritjarra Rock Hole. Water in the rock hole is sustained permanently by a regional aquifer.

Knowledge of the occupation of the area in the past is supported by a number of artefacts found at the large rock shelter. These findings were tested by radio carbon dating, as well as checked by thermo-luminescence. This has established that the zone was occupied by human groups in the period from 22 000 to 13 000 BP. From about 7 000 years ago the site was used more intensively, with the most extreme use occurring during the last 2 000 years [Smith,1989].
Puritjarra Rock Shelter is a very large shelter. At the entrance to the cave extensive rock art pecked into the rock face is evident [Flood,1990].

1.4 Native Wells - Early Explorers

With the coming of the white man to Australia, there was a desire to know more about the inland of the continent, about which most of the newcomers were totally ignorant. This and other motivations lured quite a number of enterprising men to gather groups around them, to explore the unknown interior. With the evidently dry and unpredictable climate, the need for provision of water for the expeditions, as well as for possible future development, became constantly pre-eminent.

The first great expedition in the North was lead by Dr. Ludwig Leichhardt, a German scientist who on his first trip in 1844-45, traversed about 3 000 miles (over 5 000 kilometres) in northern Australia from Moreton Bay near Brisbane, on the east coast of Australia to Port Essington at the Timor Sea coast of Arnhem Land, one of the most northern parts of the continent.
He included in his small party two Aborigines who were to assist in communication with local inhabitants. But they also had to help with other tasks, like minding the beasts, to check out the creeks and water holes. Dr. Leichhardt in his expedition travelled generally in a west and north-west direction. He followed, where possible river and creek beds with a great number water holes. He described his expedition in some detail in his book which was published not long after he had returned [Leichhardt, 1847].
Records show that Leichhardt generally attempted to remain on best of terms with the Aborigines, who usually pointed out the creeks and Native Wells along the route selected. These rivers, creeks and wells, of which the local Aboriginal groups were aware, provided essential water supply to the members of his expedition and their beasts.

Leichhardt's following expedition commenced in 1847. However it had a tragic ending, which is shrouded in mystery. Practically no records of remains of the expedition could be found and contradictory accounts have prevailed [Connell (8)].

Of other expeditions into the interior, Ernest Giles' travels in 1889, mainly within South Australia, were most important. He covered many miles which he described graphically in his book "Australia Twice Traversed: The Romance of Exploration." Inter alia he mentions the encounter and use of numerous Native Wells and even two or three Native Dams [Giles, 1889].
There are a great number of Native Wells throughout the continent, however most are not necessarily associated with early explorers but have been knowingly used by the native populations for hundreds of years.

1.5 Simpson Desert

About 20% of the land area of Australia is desert. Yet even in some of these uninviting arid areas Aborigines were living with the security of knowledge of the available water some times below surface level. Numerous expeditions into the Simpson Desert were undertaken at various times in the past. Mr. Warren Bonython, traversed the Simpson Desert with a specially designed equipment in 1973. He wrote a detailed account of his expedition in his book "Walking the Simpson Desert" [Bonython, 1980].
The book includes a map indicating the routes travelled by various explorers to the Simpson Desert. Also indicated on that map is the route which David Lindsay, a liscenced surveyor of South Australia, travelled in 1886 from Dalhousie Station, north of Adelaide, eastwards towards the location of several Native Wells in the Simpson Desert.

There was habitation around most of the wells at the time of Lindsay's visit. Access from the surface to the water at the wells was sometimes difficult and not straight forward. However the complex delineation of the shafts protected the available water in the well from evaporation and disturbance. In some cases the access to the well is "...so small ... that I had to take off my clothes before I was able to go to the water....The water bubbles up slowly and I think is a spring." [Lindsay, 1886].

An academic expedition in 1983 followed the 1886 route, with the help of some surviving natives from the Wangkangurru people.,That is the Aboriginal group who used to live in that area. Location of the wells was sometimes difficult to find and not straight forward in a predominantly adverse landscape. All the nine wells reported by Lindsay in the western Simpson Desert were relocated by that party [Hercus and Clarke, 1986].
The find of nine wells in the western Simpson Desert, which had all been at one time centres of habitation for groups of the Wangkangurru Aborigines, but now abandoned, indicates that these people, at another time had the remarkable ability to locate and treasure water available below ground level in difficult surroundings.

2. FISH AND EEL TRAPS

2.1 Lake Condah, Victoria

An example of one of the most extensive systems of fresh-water fish and eel traps is located at Lake Condah in Western Victoria. In prehistoric times Aborigines constructed an elaborate network of canals and traps in the water course connecting Condah Swamps with Lake Condah and linked to Darlot Creek. After heavy rains Lake Condah would rise, the lower channels and traps would be flooded. Water began to spill into rocky hollows and form pools, activating another series of traps downstream.
The system consists of stone walls built to form funnel shaped water courses, directing the flow of water, causing the fish to swim into the narrow ends of these channels. The stone walls are formed from blocks of volcanic basalt, which litter the district. These walls were up to one meter high and more than 50 meters long. At the ends of these channels gaps were left, where the fish could be caught in nets, woven from reeds and possibly other materials available in the proximity.

These channels formed by built up rockS were linked with canals, up to one meter deep and nearly 300 meter long. The tools to excavate the canals were wooden digging sticks. The Aborigines understood the hydrology of the Lake and its water system and used it to full advantage. Eels were probably the main species caught during their annual migrations, upstream in spring and downstream in autumn. It has been estimated that a good number of animals could be caught once the eels were active in the water course. Probably no more than 20 people were required to operate the traps once they were built. The practice of the Aborigines harvesting the fish persisted even after arrival of the white man and was recorded in some detail at the time. [Robinson, 1841],
There were later archaeological analysis of the functioning of the traps. [Coutts, 1978], Apparently there was extensive activity in the area in times of prehistory which was assumed to be semi-sedentary.I was examined in great detail by Lourandos, (1976.

2.2 Brewarrina, Barwon River, New South Wales

Another fresh water fish trap exists in north-western New South Wales. It consists of a complex maze of weirs and pens of varying size and shape erected across the Barwon River.
The fish trap structure stretches along about 750 metres of the river, on a low bar of sandstone. Most enclosures are tear-drop shaped, with the convex wall facing upstream. The stone walls are between half and one meter in height and about a meter at the base. In the spawning season, in the spring, vast numbers of fish would travel upstream.

As soon as enough fish had entered the trap, men and women would block up the openings. The fish were then herded into smaller enclosures, where they could be speared, clubbed, or caught more easily by hand. Pens at different heights came into operation in sequences, as the water level in the river rose or fell. Great care was taken that no fish should escape and might warn their fellows "about the ingenuity of their enemies"[Dargin, 1985].

The fish traps at this location used to be generally kept in good repair. However with the coming of the white settlement in the area , some of the stones were removed or used for other structures. A mission station was established some distance from the river, the Aboriginal population declined and a very different lifestyle allowed the fishery to partly fall into disrepair. More recently changed circumstances gave rise to Aboriginal initiative for the establishment of a cultural centre at the fish trap site, in the township of Brewarrina.

2.3 Hinchinbrook Island, North Queensland

Along the North Queensland coast, separated from the mainland by a drowned river channel, is the attractive Hinchinbrook Island. Numerous fish traps can be found mainly along the northern part of the island.
The low walls of the fish traps here are cemented together with rock oysters, thus resisting tidal movement. With the retreating tide the fish are caught in the traps and easily available [Thorsborne, 1988].
Obviously good knowledge of the tides and fish movement as well as perhaps some apparent encouragement of oysters to act as cementing medium, show remarkable expertise in exploitation of natural phenomena, to build structures which would make food resources readily available.

2.4 Other Coastal Fish Traps

Quite a number of coastal fish traps with walls of similar shape and construction to those described above exist along the coast of New South Wales and also on the coast of Western Australia.

SUMMARY AND CONCLUSIONS

Throughout the large continent of Australia a fair number of ancient water structures exist. They date back thousands of years, indicating a highly developed culture, going back over this extensive length of time in prehistory. The concern with hydraulic structures in various forms, natural and man-made, shows a high degree of expertise in finding and preserving water and food resources from the water, in a variety of environment. It would also appear that this skill of the Aboriginal Australian people, was applied from the earliest periods, in sometimes extremely adverse conditions. At the same time the work was carried out with simple tools and only natural materials were used. It was inherently an integral part of the culture. They built canals and water courses though levels and grades were determined by eye, optical instruments were not considered. For their construction neither ceramics nor metals were ever developed or used.

Concern with water by the Aboriginal people was consistently significant throughout the ages. It was important in view of the relative shortage of rainfall and run-off, independent of wether they were living in close proximity of the ocean shore, in areas where fresh water was available in creeks or rivers, or in the dry sometimes desert, inland areas.

From the records of the various communities living in prehistory Australia, there is evidence of an expertise in what we, in our present culture, might term water engineering. They exploited the resources throughout Australia with great skill, with understanding of drought and storm flows in water courses, knowledge of linking lakes, rivers and creeks, possible location of ground water which could be reached and which was carefully protected.
In comparison with other cultures, dating back to the very distant past, it compares favourably in their great skill in this area of human endeavour.

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AUTOMATIC REGULATION OF CANAL

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1 ABSTRACT

Automatic regulation of canals is an important operational method to increase the efficiency of the irrigation network through operation. This paper concentrates on developing a supervisory canal regulation methodology (SCRM) for on-line supervisory control of multi-reach multi-offtake, prismatic, straight, and storage backed canal systems. This method allows the canal system to be operated on an on-demand basis from a central location.

SCRM requires several algorithms. An attempt is made in this paper to formulate the several problems and provide the necessary algorithms. To decide the control action, SCRM utilizes periodical i)multiple water level measurements, and ii)gate openings. It does not require any information about pool or lateral discharges to decide the gate movements of the various gates. The control logic is based on a variable target control volume approach. The proposed regulation chain is so designed that detailed unsteady flow simulation algorithms are avoided. Calibrated gate discharge coefficients are not required input as gate discharge coefficient is considered a variable.

Adequacy of the proposed SCRM methodology is demonstrated through its application to an existing canal in Egypt; called El-Nasr canal.

2 GENERAL

Figure 1 shows the necessary algorithms to decide the control actions during on-line operation of canals under the proposed SCRM. Figure 2 shows the proposed SCRM which is based on periodical information on the sensed water depths and gate opening. Output decision of the central control System are the control actions (movements of the control gates), required to maintain the functional, hydraulic and operational requirements in the different canal pools. These control actions are supposed to be downloaded (transmitted) to the Remote Terminal Units (RTUs) to perform the action.

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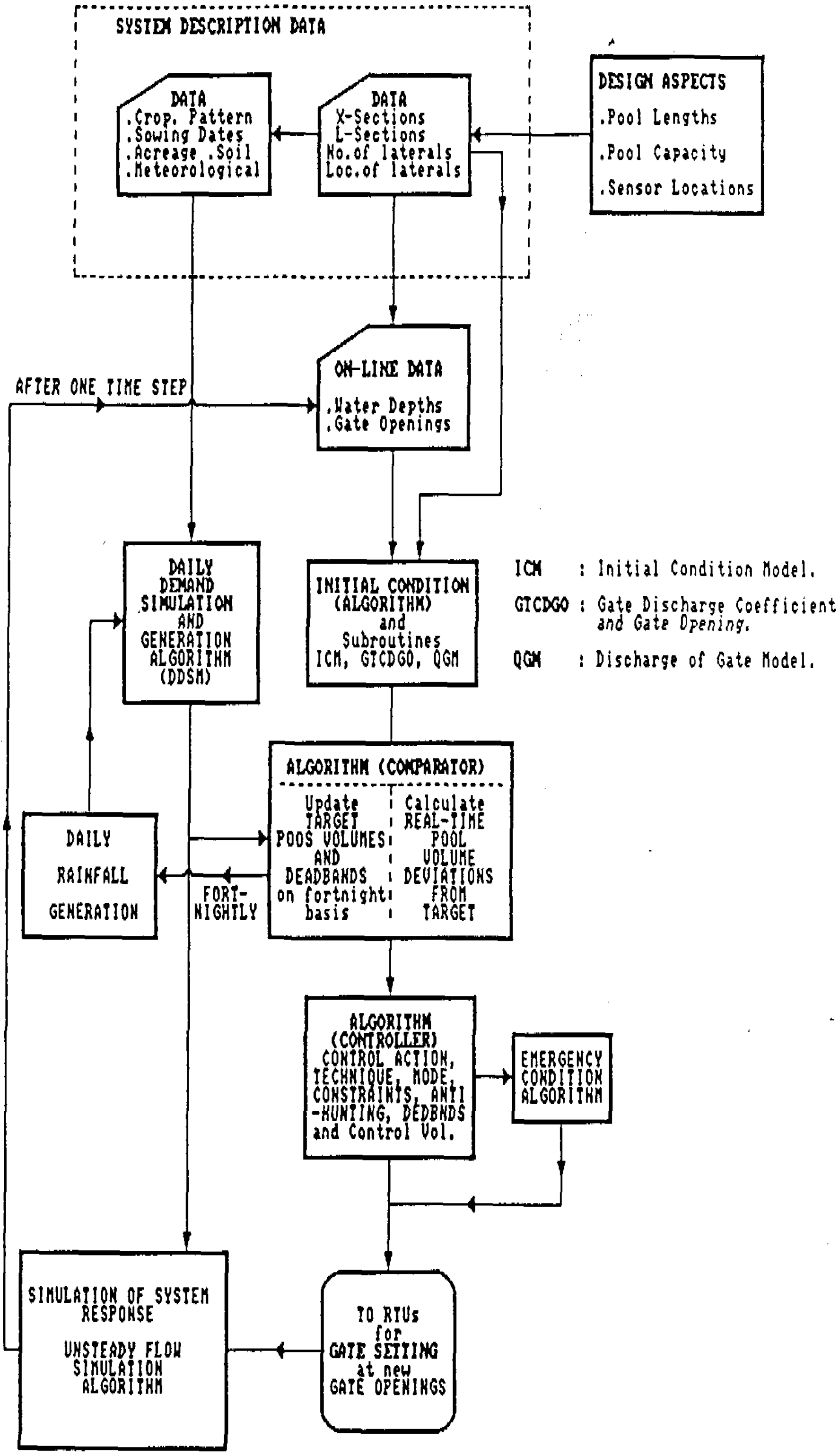


FIG. 1 FLOW DIAGRAM OF THE STUDY COMPONENTS (METHODOLOGY).

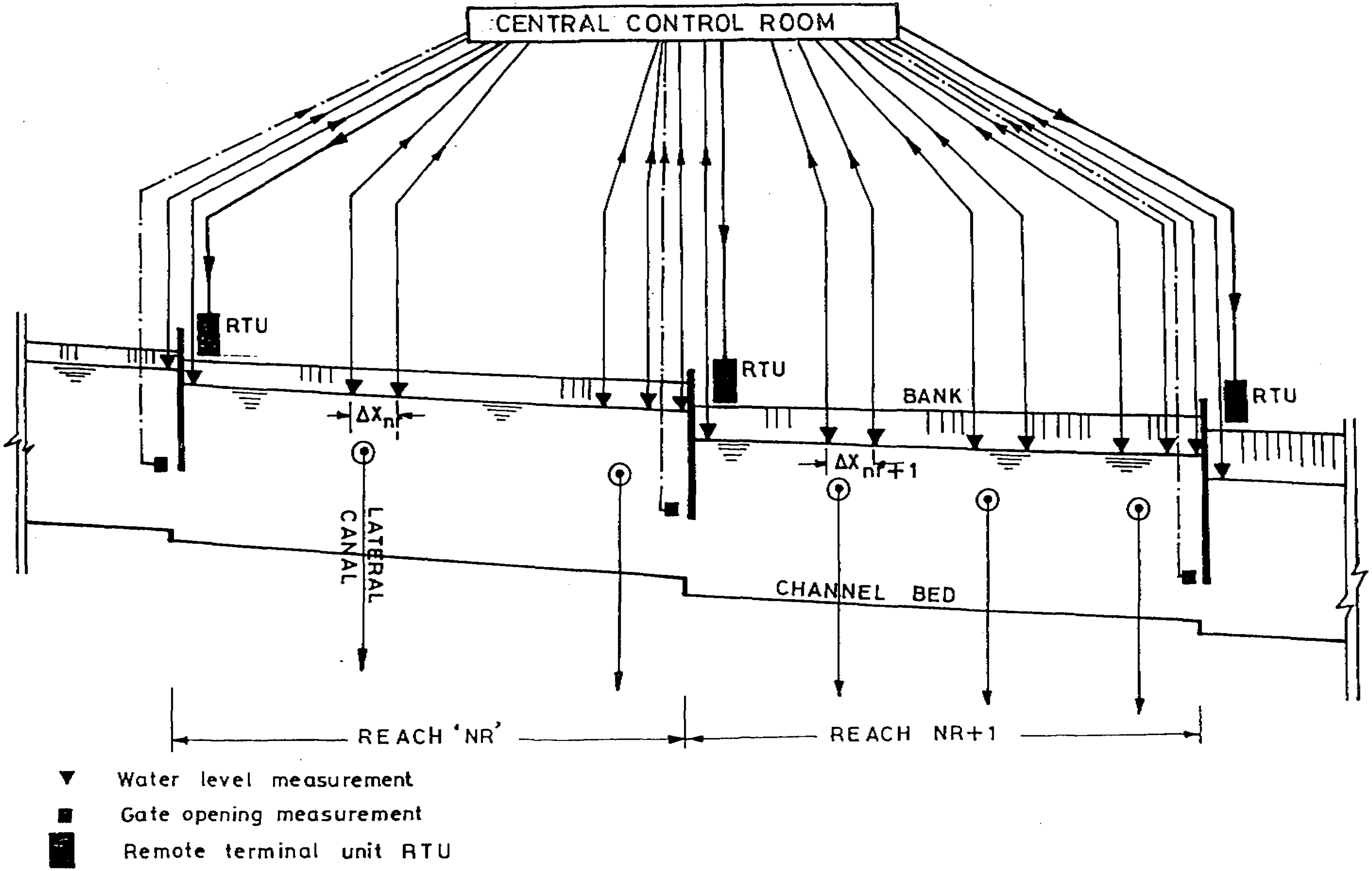


Fig. 2 Definition Sketch of Proposed Control System.

The targets for developing the proposed SCRM are;

i. Providing a supervisory control of multi-reach multi-offtake irrigation canals;
ii. Providing maximum flexibility to water users by operating the canal on an on-demand basis;
iii. Considering the hydraulic status within the canal reaches and the interaction between the different canal reaches in the control algorithms;
iv. Providing smooth transitions to target pool volumes, automatically from a remote central location;
v. Avoiding overcorrection and frequent gate movements actions after sudden changes in lateral flows;
vi. The control actions should satisfy several safety, functional, hydraulic and operational requirements;
vii. The proposed control algorithm should be based solely on periodical water level measurements and gate opening measurements without the need for discharge measurements along the main canal and laterals. Equidistant water level measurements are avoided.

3 SUPERVISORY CANAL REGULATION METHOD (SCRM)

The canal system, as defined in Figure 2, has NRT number of reaches (pools). Every reach 'nr' may supply water to nlc number of lateral canals. SCRM aims to provide on-demand water withdrawal by laterals. To provide maximum flexibility to water users, decision on water use by individual water users belonging to a lateral is assumed to be taken by the users themselves. Also, decisions to change the lateral canal discharges are assumed taken by the users themselves. SCRM is directed to maintain minimum feasible target pool volumes, calculated to ensure sufficient head for operation of offtakes. SCRM contains five interconnected algorithms i) INITIAL CONDITION, ii) COMPARATOR, iii) CONTROLLER, iv) DEMAND SIMULATION and v) EMERGENCY CONDITION.

4 INITIAL CONDITION ALGORITHM :

The Initial Condition Algorithm (ICM) receives the current sensor readings of the water depths Y(i,nr) at the specified monitoring points and the gate opening 'go(t,nr)' of all control gates (Figure 1). Each of the monitoring point is specified in terms of section 'i' and the canal reach number 'nr' (Figure 2). Water level sensors are designed for accurate representation of pool volumes. These are located at the computational sections just upstream and downstream of every lateral canal and at pool ends. The computational sections can be obtained by dividing each pool (reach) into subreaches. The basic functions of the ICM are:

i. Calculating the [illegible] under the [illegible] control gates after updating the gate [illegible] coefficients [illegible] per the monitored water depths upstream, [illegible]stream of each gate, as well as the gate opening and geometric dimensions.
ii. Calculating the current pool volumes 'SS(t,nr)' as a function of the [illegible] levels
iii. Activating the [illegible]MPARATOR for further analysis and keeping [illegible] available for the other algorithms.

A detailed description of the computational procedure is presented in the pooster presentation of the conference.

5 ANALYSIS OF POOL VOLUMES :

The algorithm (COMPARATOR) compares the computed pool volume (at time t) with the maximum, minimum, and target pool volumes as follows;

$$e(1,t,nr) = SS(t,nr) - Smax \quad (1)$$
$$e(2,t,nr) = SS(t,nr) - Smin \quad (2)$$
$$e(3,t,nr) = SS(t,nr) - ST \quad (3)$$

Where e is a current deviation error; SS(t,nr) is the current pool volume as computed by the ICM; Smax and Smin are the allowable maximum and minimum pool volumes, based on pre-specified maximum and minimum water depth limits (from system capacity and the operational minimum required water levels 'MRLs' for offtakes); and ST is the target pool volume.

The above computed deviations (called errors) are used by the algorithm 'CONTROLLER' to decide proper gate movements. This primary function of the COMPARATOR is to be repeated every time step, DT, to supply the CONTROLLER with the up-to date status of the canal.

The algorithm COMPARATOR also computes the expected pool volumes SS(t+1,nr) after one time step and its rate of change SR(t+1,nr). SS(t+1,nr) is obtained from the best fit line, making use of the values computed at the previous three time steps and the current one.

In addition, the algorithm COMPARATOR computes the current permissible limits of gate openings as a function of current gate opening, the water depths adjacent to the control gates, the maximum gate speed, as well as the maximum design water depth of the pool and the time step for monitoring the water depths; as follows :

$$\begin{aligned} cgomx &< Ymax \\ &< ho \\ &< h2 \\ &< go(t,nr)+DT\ GSmax \end{aligned} \quad (4)$$

and

$$\begin{aligned} cgomn &> go(t,nr)-DT\ GSmax \\ &> 0 \end{aligned} \quad (5)$$

Where cgomx and cgomn are the current (on-line) maximum and minimum allowable gate openings in meters; Ymax is maximum allowable water depth at the gate's site as defined by the pool's design capacity in meters; ho and h2 are the upstream and downstream water levels w.r.t gate position; DT is the time step in seconds; and GSmax is the maximum gate speed in m/sec.

5.1 Target Pool Volumes and Limits of Variation (Deadbands)

a. Every fortnight, Daily Demand Simulation Model (DDSM) is used to compute the expected daily average Qcav(j,nr), maximum Qcmax(j,nr), and minimum Qcmin(j,nr) discharge requirements of every lateral canal j taking off from a pool nr, during the next 30 days. These data are used by the COMPARATOR to update wedge storage and target pool volume requirements as well as the deadband every fortnight,based on maximum of the total daily demand in next 30 days. Target pool volume so fixed takes care of meeting lateral discharge requirements during transient time from previous target pool volume to new target volume.

For every day within the 30 days under consideration, COMPARATOR accumulates daily average, maximum and minimum demands of the lateral canals, from downstream pool to upstream sequentially and corresponding daily average (SQcav), maximum (SQcmax) and minimum (SQcmin) pool inflow requirements. These pool inflow requirements are then converted into pool water depths and then into normal Sav(nr), maximum Smax(nr), and minimum Smin(nr) pool volumes.

The above computed water depths may be beyond the pool capacity (maximum depth) or the minimum required water depth for offtake operation 'MRLs '. In case any of the above computed water depths is beyond any of these permissible limits, it is switched to the limit and the pool volume requirements are revised accordingly. Thus, the algorithm brings the target operational zone of the water depths above the MRLs to ensure offtake operation and below the maximum limit to ensure canal safety against overtopping.

b. In addition to the normal pool volume, wedge storage has to be created in each pool to ensure that supply discharge is adequate to meet maximum demands and to contain the water level fluctuations in the wedge storage zone. COMPARATOR provides wedge storage sufficient to meet maximum lateral demands during the delay time only, instead of considering wedge storage sufficient to meet full day water requirements. This is done to avoid the need for higher pool storage capacity. The delay time is defined here as the difference between the time at which the lateral flow changes and the time at which the supply water arrives at the lateral location. Therefore, delay time is considered equal to the time required for the surge wave to travel along the pool plus the time step DT.

Estimation of wave travel time (TT) is difficult in view of the unknown disturbances. A simplified form to compute the wave speed, as a function of the hydraulic mean depth ' D ' in the pool and the total pool length 'XL ', is widely used in literature which can be used herein to yield the wave travel time in the form;

$$TT = XL \; / \; SQRT\,(gD) \qquad (6)$$

Total pool length 'XL ' is considered instead of length upto lateral due to the difficulty in predicting which lateral discharge will change and the amount of change during on-line operation. Considerations of total pool length will result in computing a little longer delay time and hence slightly higher target pool volume.

By considering the expected average, maximum, and minimum water depths, the corresponding expected average, minimum and maximum approximate wave travel time (delay time) are calculated. Wedge storage volume requirements are then computed for the pool as;

$$WSmax = SQcmx\ (TTmax + DT) \quad (7)$$
$$WSav = SQcav\ (TTav + DT) \quad (8)$$
$$WSmin = SQcmn\ (TTmin + DT) \quad (9)$$

Where WSmax , WSav, and WSmin are the maximum, average , and m inimum wedge storage in cubic meters respectively; TTmax, TTav, and TTmin are the expected maximum, average (normal), and minimum wave travel time along the pool, respectively, in seconds; and SQcmx, SQcav, and SQcmn are the maximum, normal, and minimum expected pool discharges in m /sec.

c. Deadbands are updated also as a percentage of target volumes. Alternatively it can be specified as system input by the canal system operators. The algorithm COMPARATOR considers the following equations for computing the target volume for any pool and the deadbands as;

$$\begin{aligned} ST(nr) &< Sav(nr) + WSmax \\ &< Smax(nr) \\ &> Smin(nr) \\ \text{or} \quad &= \text{Any arbitrary target volume as specified by the user.} \end{aligned} \quad (10)$$

and the deadband 'DEDBND ' is calculated as:

$$DEDBND = r\ ST \quad (11)$$

Where r is a constant to be specified by the user. Criteria for fixing r depends on the desired degree of accuracy of controlling the water levels. A small r value is preferable for higher accuracy. However, a very small r value may cause control system instability and unnecessary control gate movements.

d. The above procedure is repeated to calculate daily target pool volumes for the different pools. The same procedure (from step a) are repeated for computing target pool volumes for every day during next 30 days.

e. The algorithm COMPARATOR decides the new target pool volumes based on the above computed daily ones for the next 30 days. To ensure that pool volumes are adequate to meet maximum supply, the maximum target pool volumes are selected.

f. The above procedure for updating the target pool volumes are repeated every fortnight.

g. Once the target pool volumes are calculated, these are again checked to satisfy the maximum storage capacity constraint of the pool and to ensure positive head at the control gates.

h. The algorithm COMPARATOR compares the new target pool volumes with the current target pool volumes. Because the process of changing the target hydraulic status is a disturbance in itself, the new target pool volumes are not considered in all the pools simultaneously. A sequential change of target pool volumes is made to ensure stability and unidirectional flow as well as positive head at the control structures.

6 GATE DISCHARGE SCHEDULE AND GATE OPENINGS :

Any canal regulation method includes an algorithm to decide the control action. This algorithm is the heart of the control process. In this paper, this algorithm is called CONTROLLER. It is designed to perform the following functions;

i) Checking whether the existing operation condition is an emergency type or normal. This is done by activating Emergency Condition Algorithm (ECA). ECA checks whether water levels in the main canal are within the specified limits for normal operation. In case these limits are not satisfied the ECA warns and takes appropriate control action. If the water levels are within the specified limits, the ECA returns the control process to normal control mode in the algorithm CONTROLLER. CONTROLLER carries out the following functions under normal control mode :

ii) Computes required discharge at upstream gate of each pool so that each pool maintains its target volume and satisfies a set of functional, hydraulic and operational requirements; and

iii) Decides the new gate openings by converting the computed gate discharges into feasible gate openings.

Control Procedure

In general, as shown in Figure 3, gate discharges schedule required to balance the pool volume deviations from the target volume within one time step are calculated. The procedure is repeated from downstream to upstream pools. In case any change in the pool's upstream gate discharge is required, the same change is added to all other upstream gates to provide an instantaneous and simultaneous gate response. The resulting gate discharges are then checked to satisfy several other gate discharge requirements as will be explained below. In case the calculated gate discharges do not satisfy the discharge requirements, the gate discharge is revised and the same discharge modification is algebraically added to all upstream gates.

When the generated gate discharges satisfy all the gate discharge constraints, the algorithm CONTROLLER converts the gate discharges into gate openings, based on the monitored water depths rather than simulated ones.

7. APPLICATIONS AND CONCLUSIONS

Adequacy of the proposed control methodology are measured in terms of i)satisfying lateral demands (on-demand); ii)immediate response to flow changes; and iii)controlling the water levels to stabilize within a minimum possible time. Daily lateral lateral canal discharges are simulated (11) and used in this paper as random

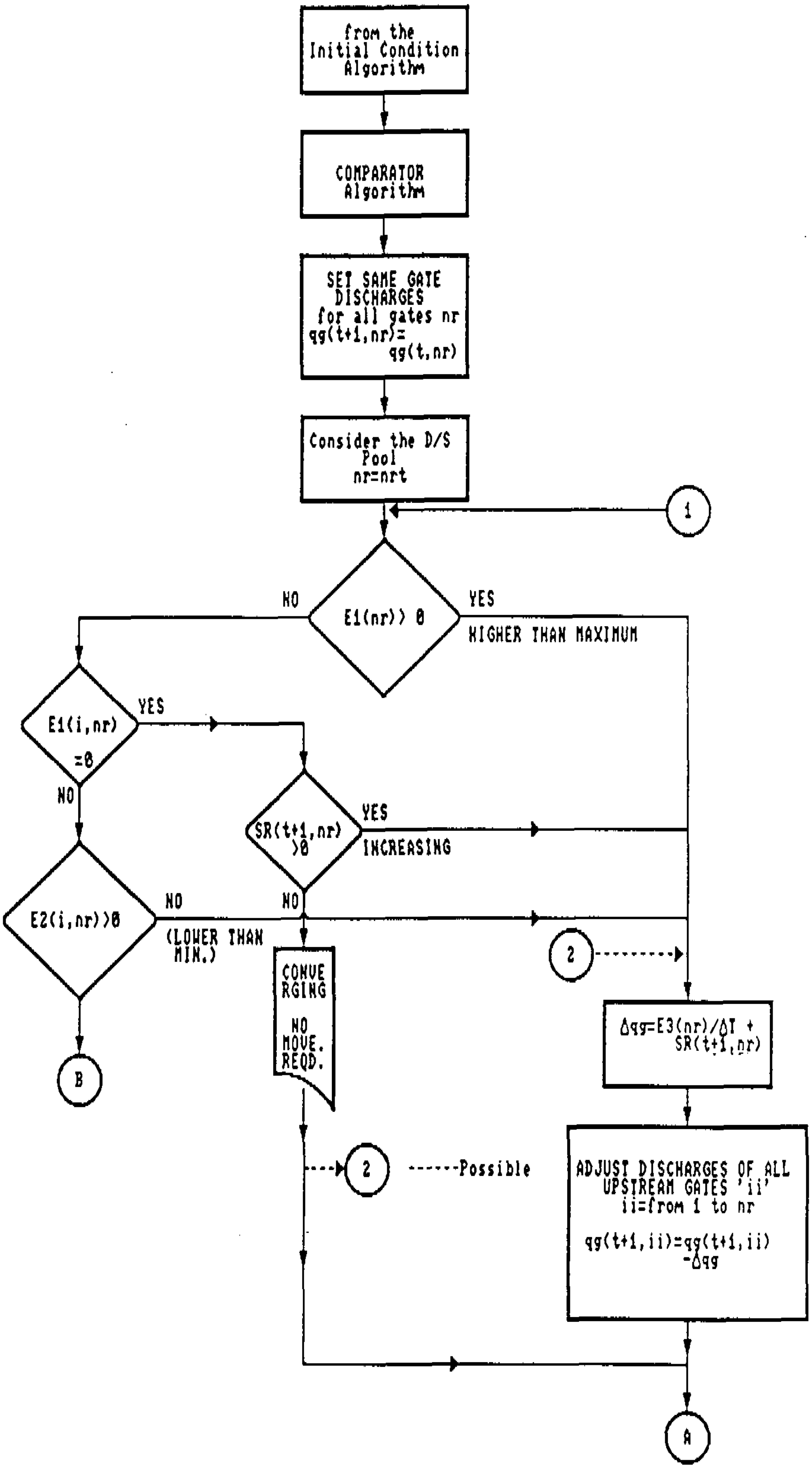
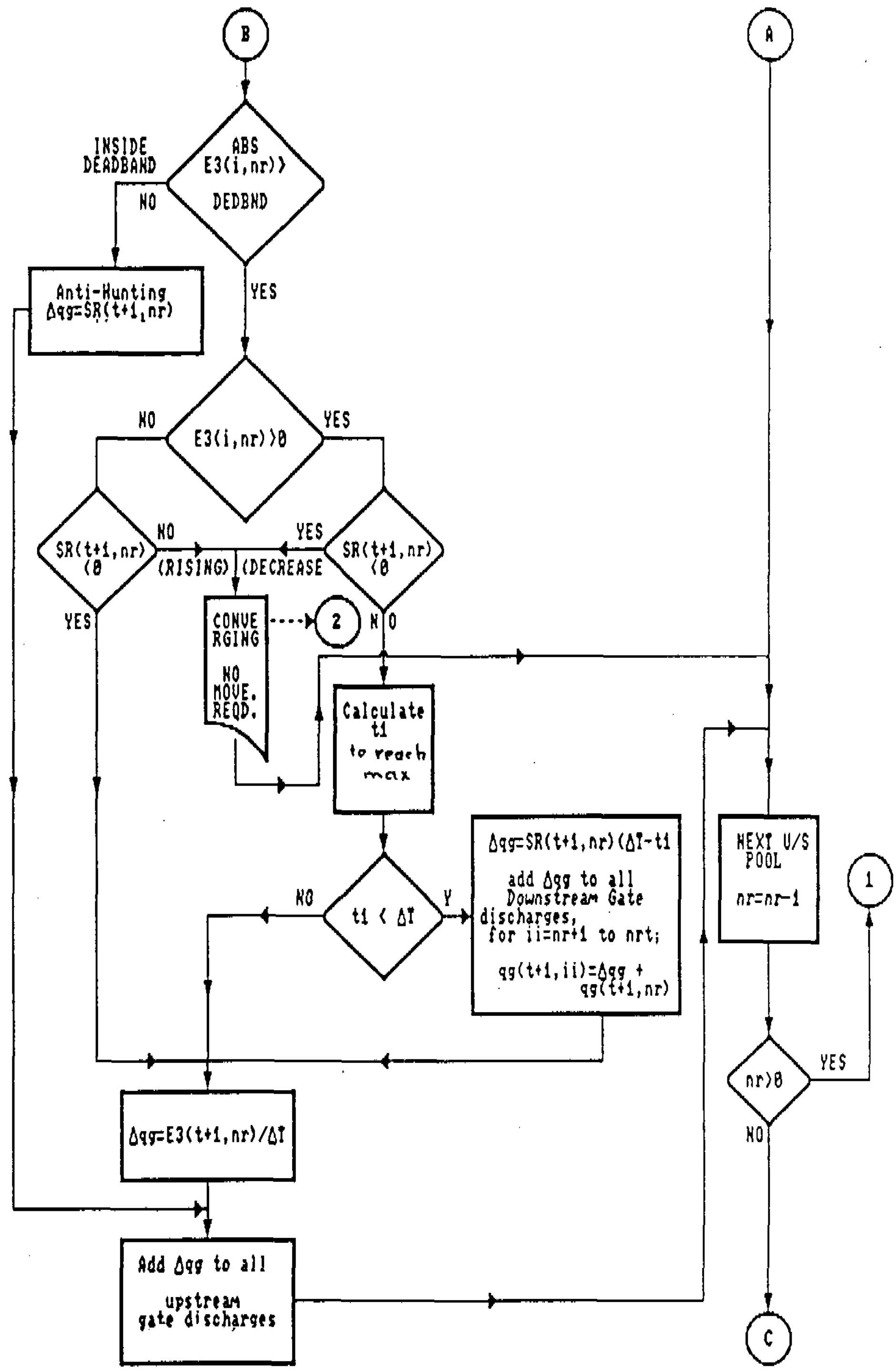


FIG. 3 FLOW CHART OF THE ALGORITHM CONTROLLER.

Fig. 3 Contd.



B
A
INSIDE DEADBAND
ABS E3(i,nr)> DEDBND
NO
YES
Anti-Hunting Δqg=SR(t+1,nr)
NO
YES
E3(i,nr)>0
SR(t+1,nr) <0
NO
YES
SR(t+1,nr) <0
(RISING)
(DECREASE
YES
CONVERGING NO MOVE. REQD.
2
NO
Calculate t1 to reach max
NO
t1 < ΔT
Y
Δqg=SR(t+1,nr)(ΔT-t1
add Δqg to all Downstream Gate discharges, for ii=nr+1 to nrt;
qg(t+1,ii)=Δqg + qg(t+1,nr)
NEXT U/S POOL
nr=nr-1
1
nr>0
YES
NO
Δqg=E3(t+1,nr)/ΔT
Add Δqg to all upstream gate discharges
C

Fig. (3.) Contd.

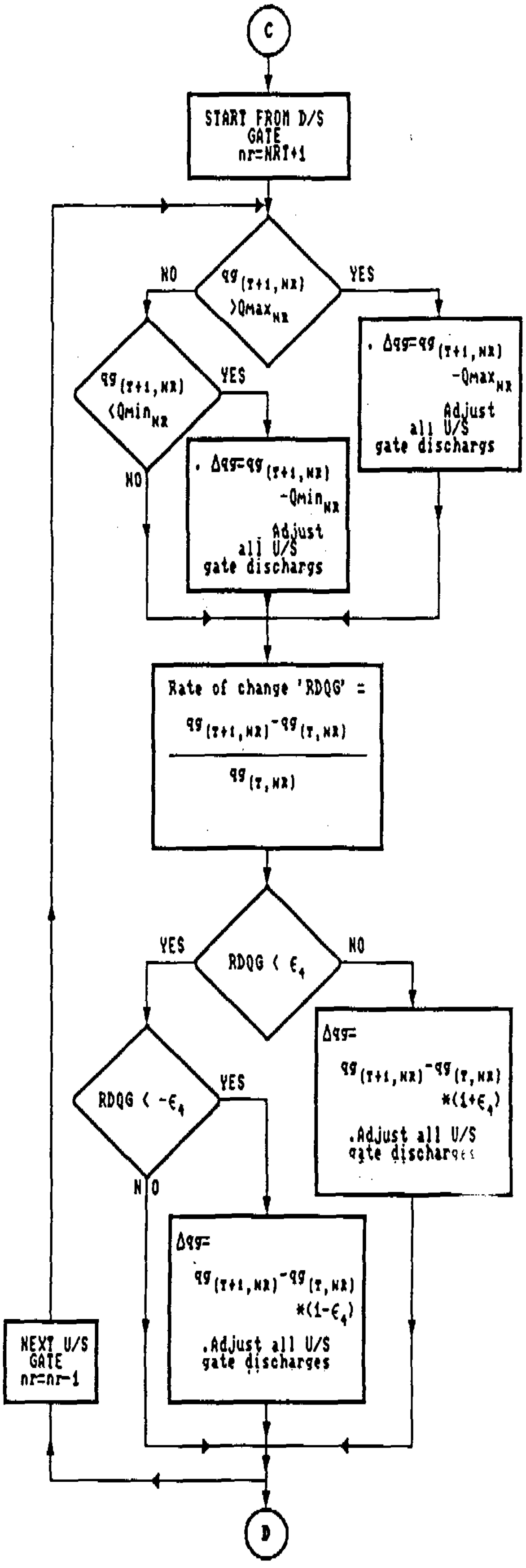
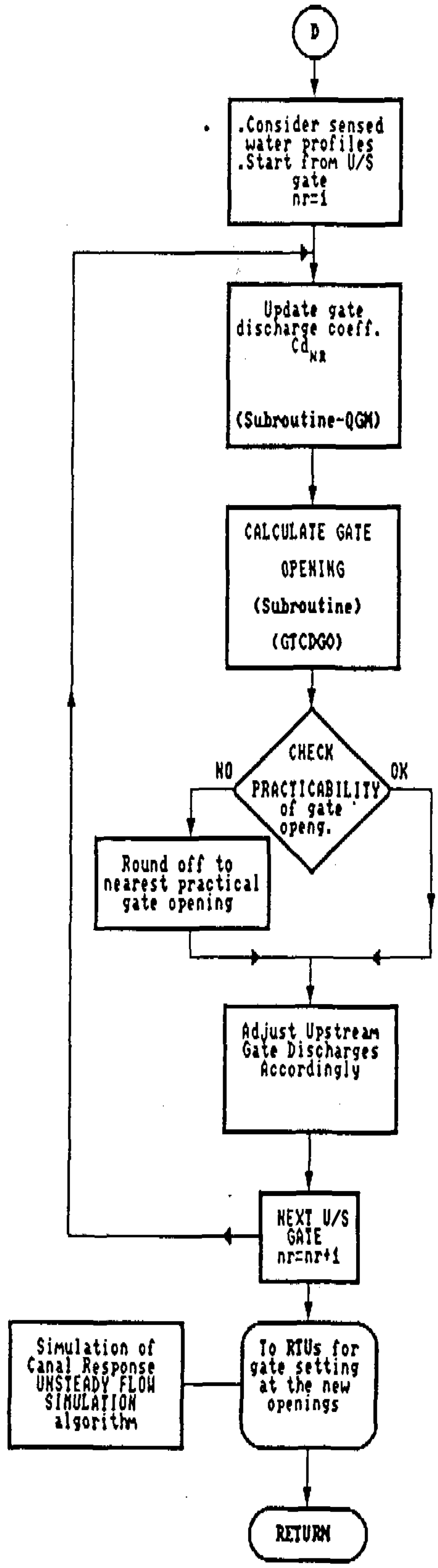

C
START FROM D/S GATE nr=NRT+1
qg(T+1,NR) >Qmax NR
NO
YES
qg(T+1,NR) <Qmin NR
YES
NO
. Δqg=qg(T+1,NR) -Qmax NR Adjust all U/S gate dischargs
. Δqg=qg(T+1,NR) -Qmin NR Adjust all U/S gate dischargs
Rate of change 'RDQG' = qg(T+1,NR)-qg(T,NR) / qg(T,NR)
RDQG < ε4
YES
NO
RDQG < -ε4
YES
NO
Δqg= qg(T+1,NR)-qg(T,NR) *(1+ε4) .Adjust all U/S gate discharges
Δqg= qg(T+1,NR)-qg(T,NR) *(1-ε4) .Adjust all U/S gate discharges
NEXT U/S GATE nr=nr-1
D

Fig. (3) contd.


D
.Consider sensed water profiles
.Start from U/S gate
nr=1
Update gate discharge coeff.
Cd NR
(Subroutine-QGM)
CALCULATE GATE OPENING
(Subroutine)
(GTCDGO)
NO
OK
CHECK PRACTICABILITY of gate openg.
Round off to nearest practical gate opening
Adjust Upstream Gate Discharges Accordingly
NEXT U/S GATE
nr=nr+1
Simulation of Canal Response UNSTEADY FLOW SIMULATION algorithm
To RTUs for gate setting at the new openings
RETURN

demands. A period of one-year is used for simulation to i)cover a wide range of variety in operation scenarios, including normal and extreme operational conditions; ii)present and evaluate the capability of the proposed control method for maintaining variable as well as constant target pool volumes and for maintaining feasible water levels; and iii)check the performance of water levels and gate response over a long period. Out of this long-term simulation results, some results are sampled and discussed.

7.1 Data and Case Studies

7.1.1 Input data

By using an unsteady flow simulation algorithm, developed to simulate the process of automatic regulation of canal(10), the proposed SCRM is evaluated. SCRM is applied to the last downstream portion (30.5 km. length) where many operational problems now exist through manual operation. The canal portion under consideration consists of four different pools separated by vertical control gates and supplies 13 lateral canals. These laterals are distributed along the four pools as shown in Figure 4. The 13 lateral canals serve a total agricultural area of 27,300 hectares. The canal is designed to serve an additional future extension of 33,600 hectares with an expected minimum daily discharge of 5 cubic meter/sec

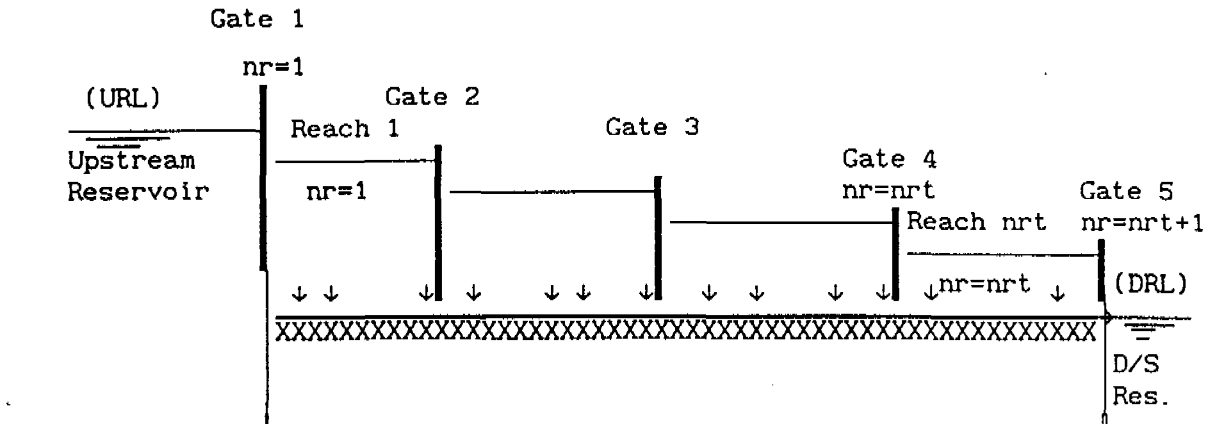
Table 1 shows the data of the physical canal system. Number and location of the water level sensors are specified as recommended above. The incremental distance DX is selected equal to 500 m for all pools. Time step required is taken 15 min to overcome the computer storage capacity limitations.

The algorithm CONTROLLER is developed for canal regulation in the presence of random variation in lateral discharges. This variation can occur at any time during the day. To reduce the lengthy outputs of the simulation program, due to the limited computer storage capacity, and to assume the worst operational condition, lateral canal discharge variations are assumed to occur at the same time; 6 O'Clock in the morning of every day. Lateral canal discharges are taken similar to the simulated discharges by (11).

In the absence of data on the tail end discharge for the future extension area, a lump sum constant discharge of 5 m3/sec is assumed. This discharge is the expected minimum design discharge along the year as reported by Halcrow(3).

7.1.2 Simulation period and case studies

One-year simulation is presented as an average operational year to i)cover a wide range of operation scenarios which can not be included in a few hour simulation period; and ii)simulate the canal operation during the different cropping seasons which extend over 5 to 12 months. The simulation study starts at January 1 and ends at December 31. During this period extreme variations in lateral demands take place. These fluctuations in lateral canal discharges(10),(11) show the extreme variation in demands especially after rainfall (a



Chainage (Km)	55.2 62.7 70.7 77.7 85.7
Bed Level (m)	50.4 .... linear 47.35
Bed Width (m)	15 10 9 7.5
Bed Slope	.... 10 cm/km ....
Normal Average Water Depth (m)	.... 2.5 ....
Bank Level (m)	55.5 54.2 54.2 53.4
Side Slopes	.... 1 H : 2 V ....
Manning's 'n'	.... 0.016 ....
Lateral Numbers	3 4 4 2
lateral	55.7 62.67 67.17 70.64 74.24 77.37 83.0
Chainage (Km)	65.98 64.92 67.55 72.24 76.52 79.70
Bank	R R R L L R R L R L L R R
Acreage in Hectares	2370 2226 1054.2 651 4520 3217.2 2184 3208 550.2 642.6 1008 529.2 5040
Total Area	(27300.4 Hectors)

R Right bank.
L Left Bank.

Fig. 4 Data of the Typical Longitudinal Section of El-Nasr Canal Portion Under Consideration.

sudden collapse in demands followed by sudden increase in demands after few days).

The following cases are analyzed;

Case 1 :
This case includes simulation of automatic regulation of El-Nasr canal subjected to the simulated external disturbances (in 10,11) of lateral canal discharges and assuming preset constant target pool volumes.

Case 2 :
This case includes simulation of automatic regulation of El-Nasr canal subjected to the same external disturbances and adopting the proposed procedure, within the algorithm 'COMPARATOR', for changing the target pool volumes.

7.2 Simulation Results (Long-Term)

7.2.1 Controlled variable (pool volumes)

Figure 5 and 6 show samples of the controlled pool volumes as related to the target volumes in the two cases mentioned above. Figure 5 shows that the control methodology is capable of maintaining constant pool volumes within the deadband (selected 1% of target volumes). CONTROLLER is successful in i)bringing the pool volumes back to the target volumes after any variation in lateral discharges (ranging from 0.0 to maximum; and ii)preventing the pool volumes from deviating away from the target volumes after the disturbance.

Figure 6 shows the capability of the algorithm COMPARATOR for changing the target pool volumes as per the expected demands. This capability adds to usefulness of the method in saving water (by reducing in-pool storage), especially at end of operation season when demands decrease. From Figures 5 and 6 one may conclude that the procedure for updating and maintaining the updated target pool volumes through the algorithm 'COMPARATOR' is satisfactory.

7.2.2 Water Depths

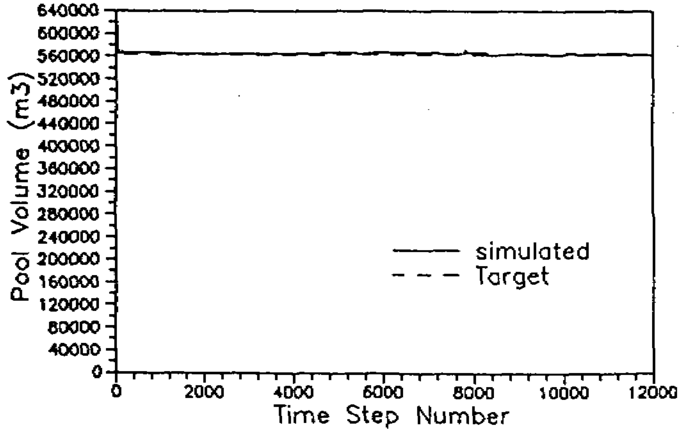
Simulated water depths of the 35000 time steps (one-year) for the two cases under consideration are plotted in Figures 7 and 8 to demonstrate the capability of the proposed 'CONTROLLER' for maintaining stable water depths along the entire simulation period. The simulated high fluctuations in water depths during high fluctuation in demands are due to the initial disturbances in the water levels, caused by the lateral discharge variations. The algorithm 'CONTROLLER' is successful in stabilizing the water levels within a minimum time due to instantaneous and simultaneous response of the control gates. It prevents the water levels from deviating more than the initial disturbance and to stabilize. It brings the deviated water levels to the new steady state profile satisfying the new lateral discharges, target pool volumes, pool capacity and water level requirements. The calculated target pool volumes ensure that any disturbance in water levels is always higher than the operational minimum required water levels for lateral canals and the normal water

Table 1 El-Nasr Canal Data used for Simulation Study.

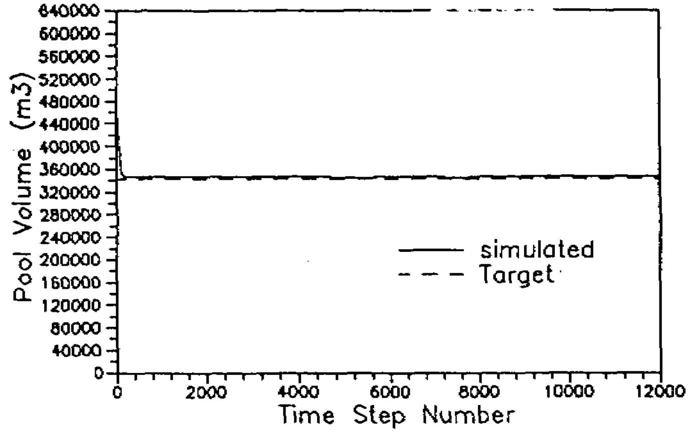
Parameters	Value
Number of pools	4
Length of pool, m	7500, 8000, 7000, 8000
Canal bottom slope, m/m	0.00010
Canal bottom width, m	15, 10, 9, 7.5
Canal side slope, m/m	0.5 H : 1 V
Manning roughness coefficient	0.016
Number of nodes per pool	16, 17, 15, 17
Upstream Reservoir Water depth above canal bed (invert), m	8.5
Downstream Reservoir Water depth above canal bed (invert), m	0.0
Number of laterals	3, 4, 4, 2
Number of water level sensors	6, 9, 9, 6
Required flow rate at end m3/s	5.0
Gate width, m	8, 8, 8, 8, 7
Gate height, m	5, 5, 5, 5, 5
Gate speed (max) m/s	0.03
Gate speed (min) m/s	0.00000001
Gate discharge coefficient	Variable
Time step T, min	15
Duration of simulation	One year (35000 time step)
Disturbances	as per simulated demands

Table 2 Cases Used for Presenting the Detailed System Response.

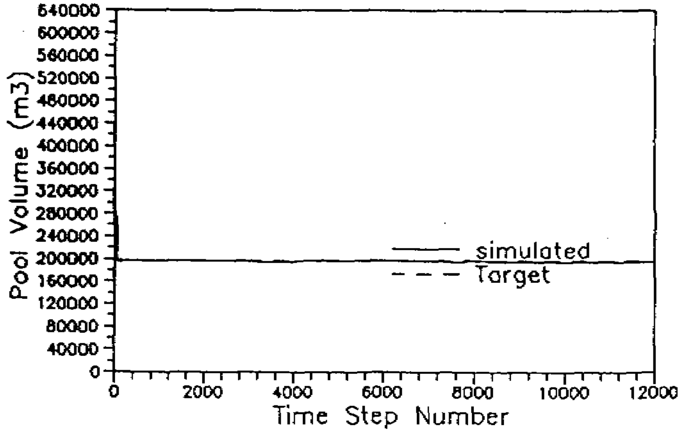
CASE NO	DEFINITION	DATE	DAY SERIAL NUMBER	TIME STEP No.	OPERATION SCENARIO
1	El-Nasr canal with constant target pool volumes	June 15	167	15961	Normal rise in demands.
2	El-Nasr canal with variable target pool volumes	June 15	167	15961	Same as case 1.
3	Hypothetical canal with variable target pool volumes	June 18	170	16249	Sudden Drop in Demand Due to Rainfall.
4	Hypothetical canal with variable target pool volumes	June 20	172	16441	Sudden demand.



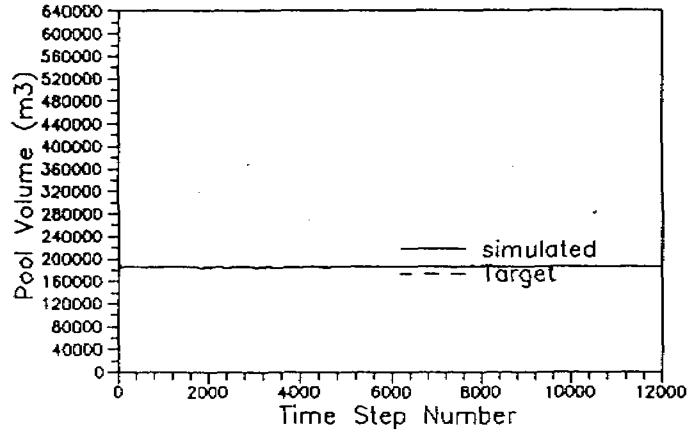
a. Pool number (1) Upstream.



b. Pool Number (2).

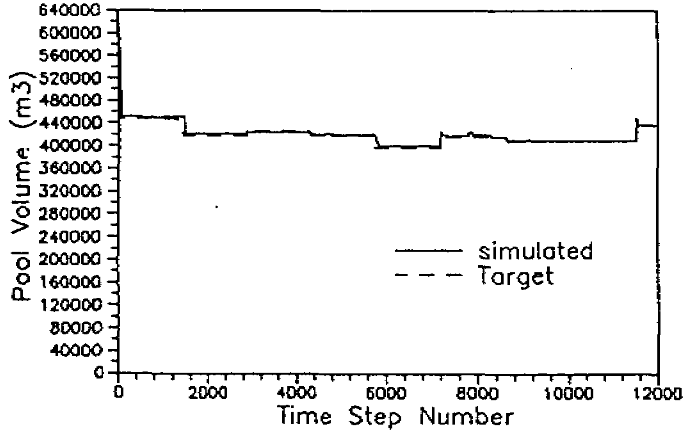


c. Pool Number (3).

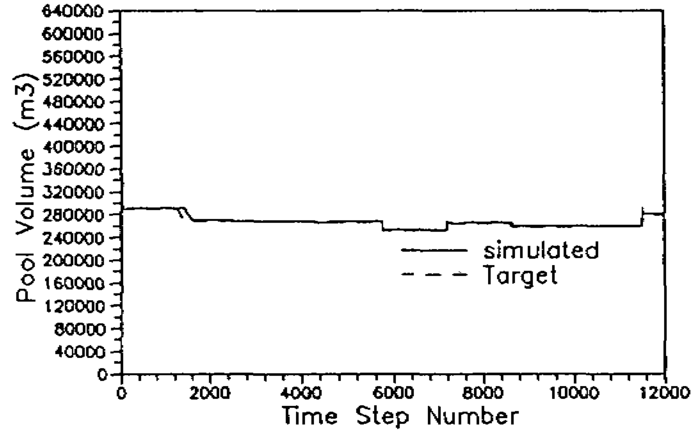


d. Pool Number (4) Downstream.

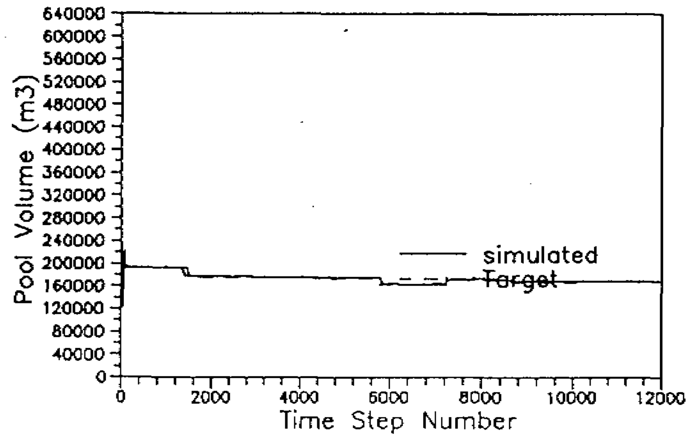
Fig. 5 Long-Term Simulated (Controlled) Pool Volumes and the Fixed Target Pool Volumes. Case 1.



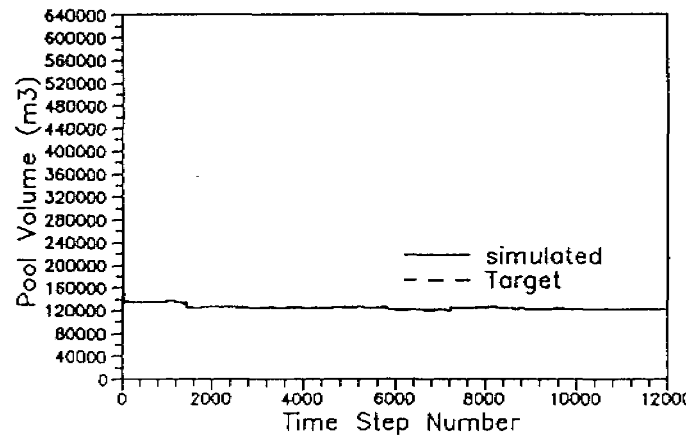
a. Pool number (1) Upstream.



b. Pool Number (2).

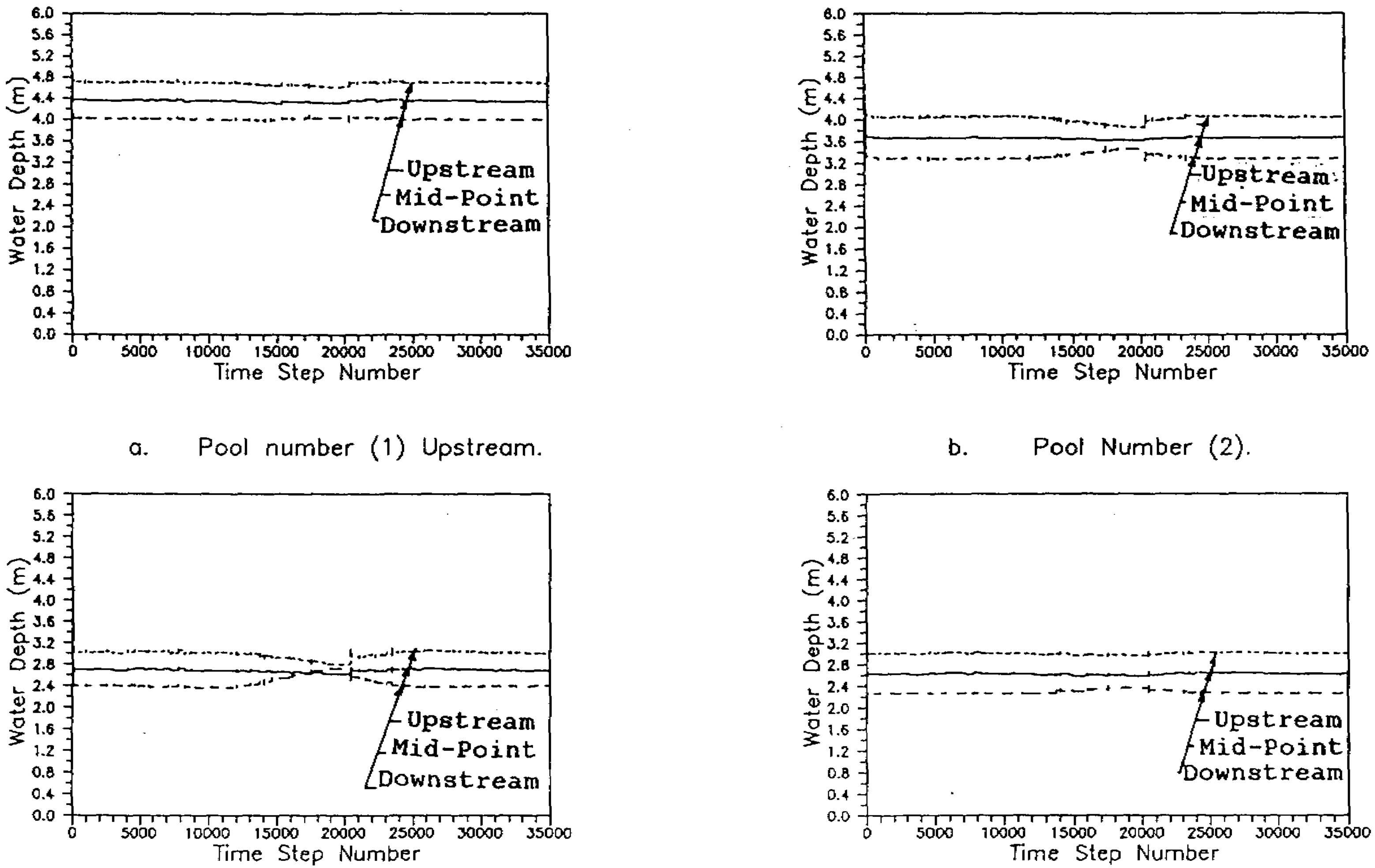


c. Pool Number (3).



d. Pool Number (4) Downstream.

Fig. 6 Long-Term Simulated (Controlled) Pool Volumes and the Updated Target Pool Volumes. Case 2.



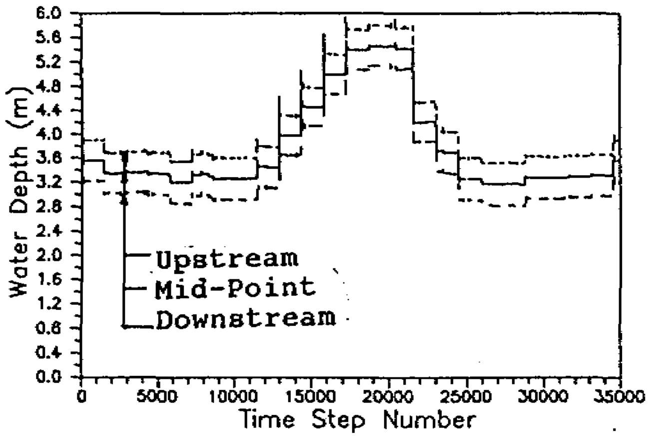
a. Pool number (1) Upstream.

b. Pool Number (2).

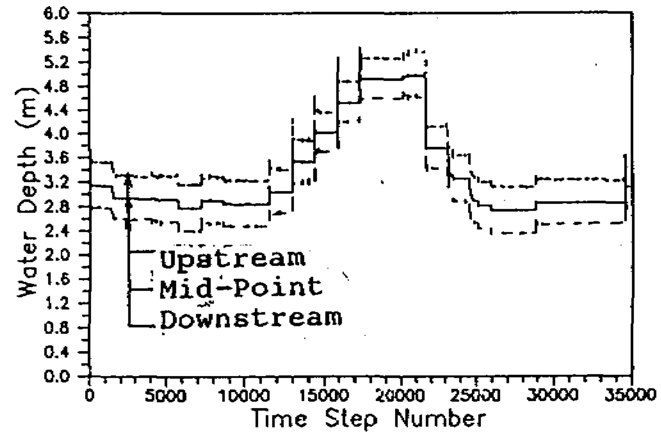
c. Pool Number (3).

d. Pool Number (4) Downstream.

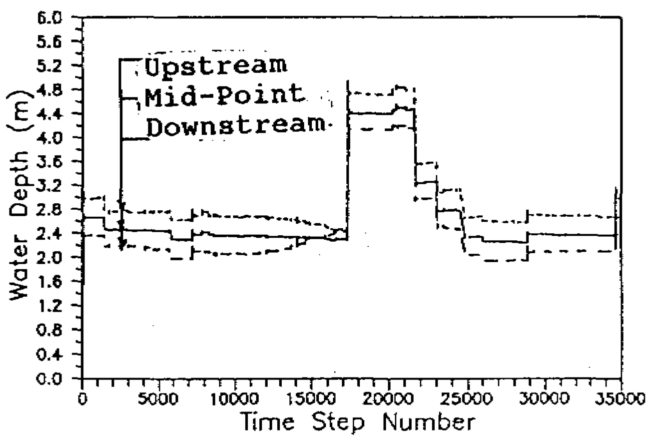
Fig. 7 Long-Term Simulated Pool Water Depths. Case 1.



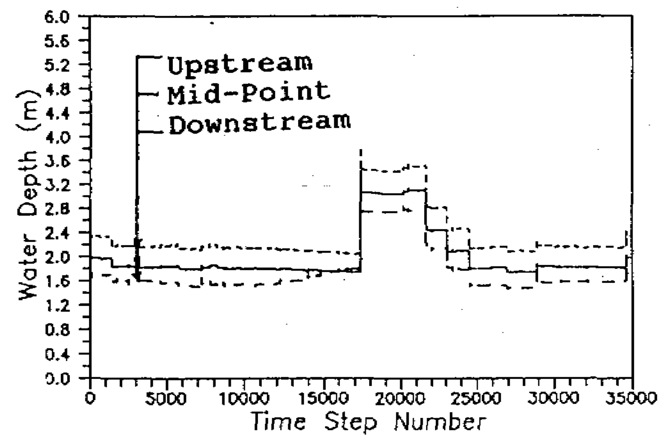
a. Pool number (1) Upstream.



b. Pool Number (2).



c. Pool Number (3).



d. Pool Number (4) Downstream.

Fig. 8 Long-Term Simulated Pool Water Depths. Case 2.

depth.

Figure 7 shows the water depths in the four pools of El-Nasr canal when the target pool volume is kept constant, equals to the initial pool volumes. Figure 8 shows the water depths in the four pools of El-Nasr canal if the proposed procedure for fixing and changing the target volumes are adopted. As it can be expected, the simulated water levels remain the same and indicate steady state conditions when there is no flow disturbance. This result agrees with the logically expected performance during the steady state conditions, which is used for testing the proposed unsteady flow simulation algorithm.

From Figures 7 and 8 it may be concluded that the control logic adopted in the algorithm CONTROLLER is successful in controlling the disturbance waves to damp rather than to amplify. It is also successful in maintaining the hydraulic stability of the system and maintains the mid-point water levels while minimizing the water level fluctuations at ends of the pools.

7.2.3 Control action (gate openings)

Long-term control gate movements for the two cases under consideration are plotted in Figures 9 and 10 respectively. They show sudden increases in gate openings during changing the target pool volumes every fortnight. These rises are due to i)the need for significantly increasing the target pool volumes; and ii)the assumed high maximum gate speed. As it can be expected, Figure 9 shows that the gate openings remain constant when there are no lateral flow changes. In this period the simulated gate openings are required only to draw the tail end design discharge. This satisfactory result adds to the validation and check of the control algorithm since no control action is taken when there are no external disturbances (steady state condition).

The above long-term simulation results show the capability of the algorithm 'CONTROLLER' to maintain stable gate openings. The algorithm CONTROLLER is successful in providing smooth and converging gate movements as will be presented in the next section.

7.3 Detailed Result Samples

Out of the very lengthy simulation result files, four result samples are taken up to be presented below in detail. Each sample case presents one operation scenario. These sample cases and the satisfactory performance of the canal as well as the satisfactory gate response under the proposed control methodology are presented in details within the pooster presentation of the paper.

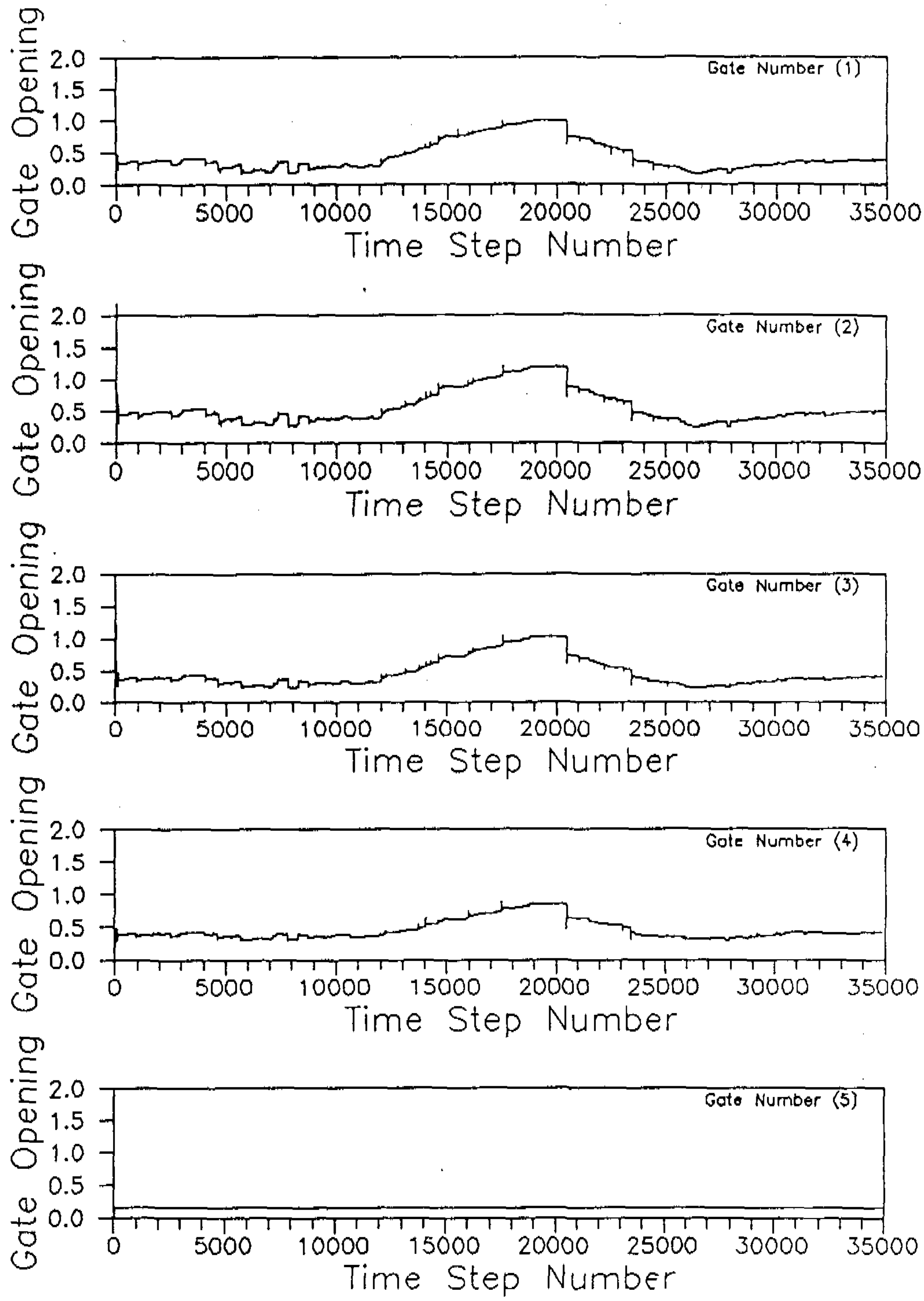


Fig. 9 Long-Term Simulated Gate Response to Lateral Flow Changes. Case 1.

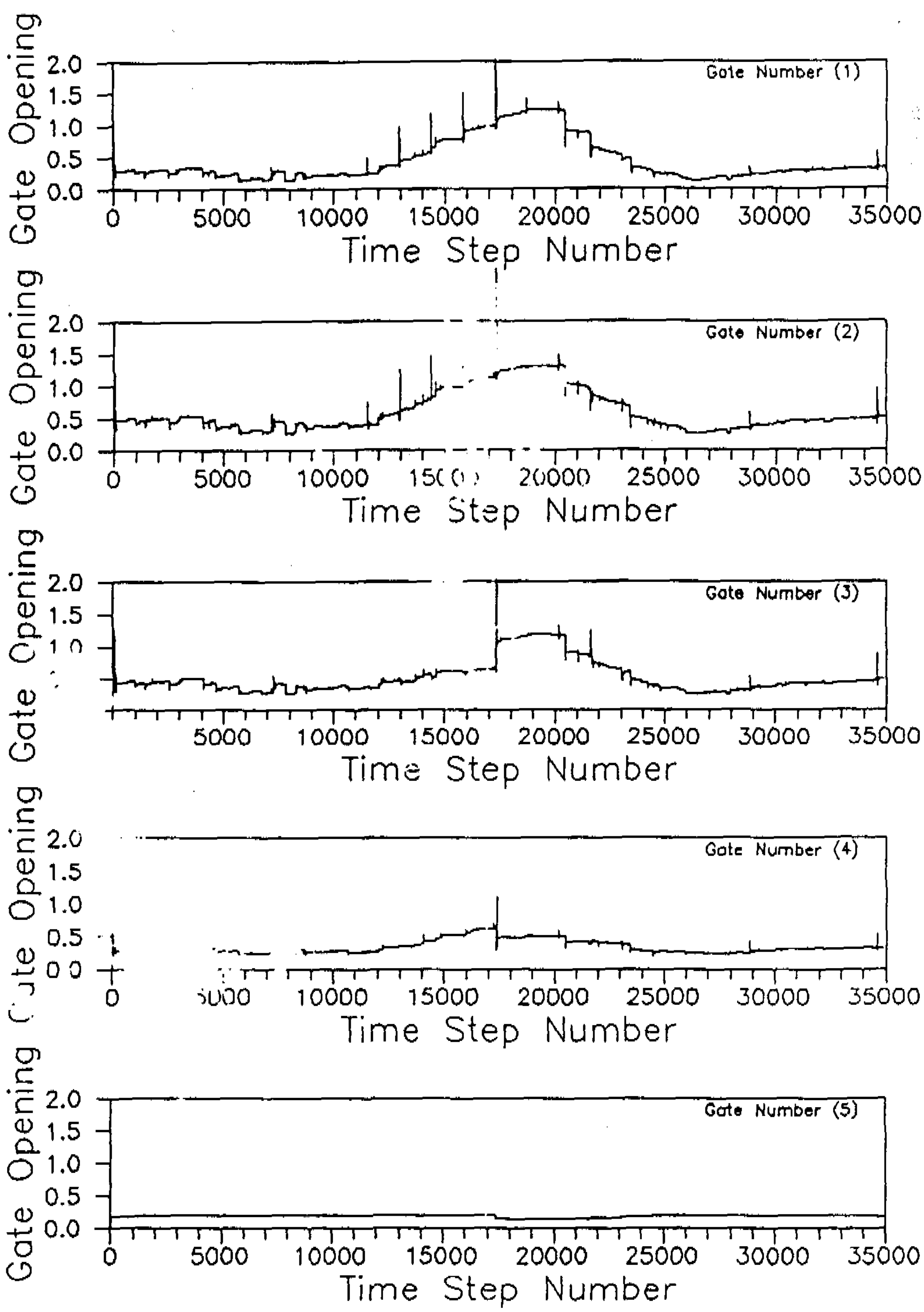


Fig. 10 Long-Term Simulated Gate Response to Lateral Flow Changes. Case 2.

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A STEP BY STEP METHODOLOGY TO DEVELOP A CENTRAL LABORATORY FOR ENVIRONMENTAL QUALITY MONITORING

T. A. Tawfic and S. El-Guindy*

SCOPE

Demands on the limited water supply in Egypt is increasing due to rapid increase in population and the much needed economic development. Decision makers concerned with the management of limited water resources are in need for various comprehensive and accurate data. Those decision makers in addition to private citizens are interested in water quality data, because of its serious environmental effects.

Pesticides, fertilizers, industrial wastes and raw sewages, have contributed to the contamination of water intended for human consumption and irrigation.

The Ministry of Public Works and Water Resources (MPWWR) represented by the Water Research Center (WRC) was one of the first governmental agencies to address the degradation of water quality.

WRC needed to develop and consolidate its existing laboratories and establish a modern central laboratory for environmental quality monitoring to produce data of known quality and accuracy that can be used in the national monitoring programs.

This laboratory should provide a comprehensive and accurate assessment for environmental quality of surface water, groundwater, and soils associated with the River Nile, and its water distribution and collector network of channels, reservoirs and aquifers.

This poster illustrates the charts[1] of the main elements and activities incorporated in PRIMAVERA Project Management System, in order to create the Central Laboratory for Environmental Quality Monitoring. The poster also shows the organizational structures and the final laboratory layout.

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1 Charts obtained from RNPD-II, Inception Report, Volume II, Component A3, 1994.

Figure 1: Work Breakdown Structure Incorporated in the PRIMAVERA to Establish the CLEQM.

- **Personnel Training**
  - Assessment of Educational Background
  - Training Program Elaboration
  - Implementation of Training Program
    - On-the-job training
    - Post-graduate fellowships (Egypt)
    - Workshops, seminars, etc. (Egypt)
    - Short term courses (Egypt)
    - Overseas short courses, training, etc.
    - International conferences
    - Library
- **Quality Control/Assurance**
  - Review of QC/QA Procedures Available
    - Quality control program
    - Quality assurance program
    - Specific training to laboratory staff
  - Selection and Adaptation of QC/QA Procedures
  - Preparation of QC/QA Procedures Manual
  - Implementation of QC/QA Procedures
- **Data Processing**
  - Finalization of Needs for Data Base and Interpretation
  - Implementation of System
  - Data Base Management System Implementation
  - Data Interpretation System Implementation
- **Twinning**
  - Elaboration of Twinning Program
    - Identification of pertinent twinning areas
    - Identification of institutions for twinning
    - Elaboration of program & arrangements
  - Implementation of Twinning Program
    - Institutional staff exchange (Egypt to Canada)
    - Institutional staff exchange (Canada to Egypt)
    - Organizations of conferences, etc.
- **Reporting**
  - Definition of Scope for Information Reporting
  - Defintion of Format and Frequency for Reporting
  - Reports on Water and Soil Quality
  - Data Dissemination
  - Coordination and Exchange of Information

Figure 1 (cont.): Work Breakdown Structure Incorporated in the PRIMAVERA to Establish the CLEQM.

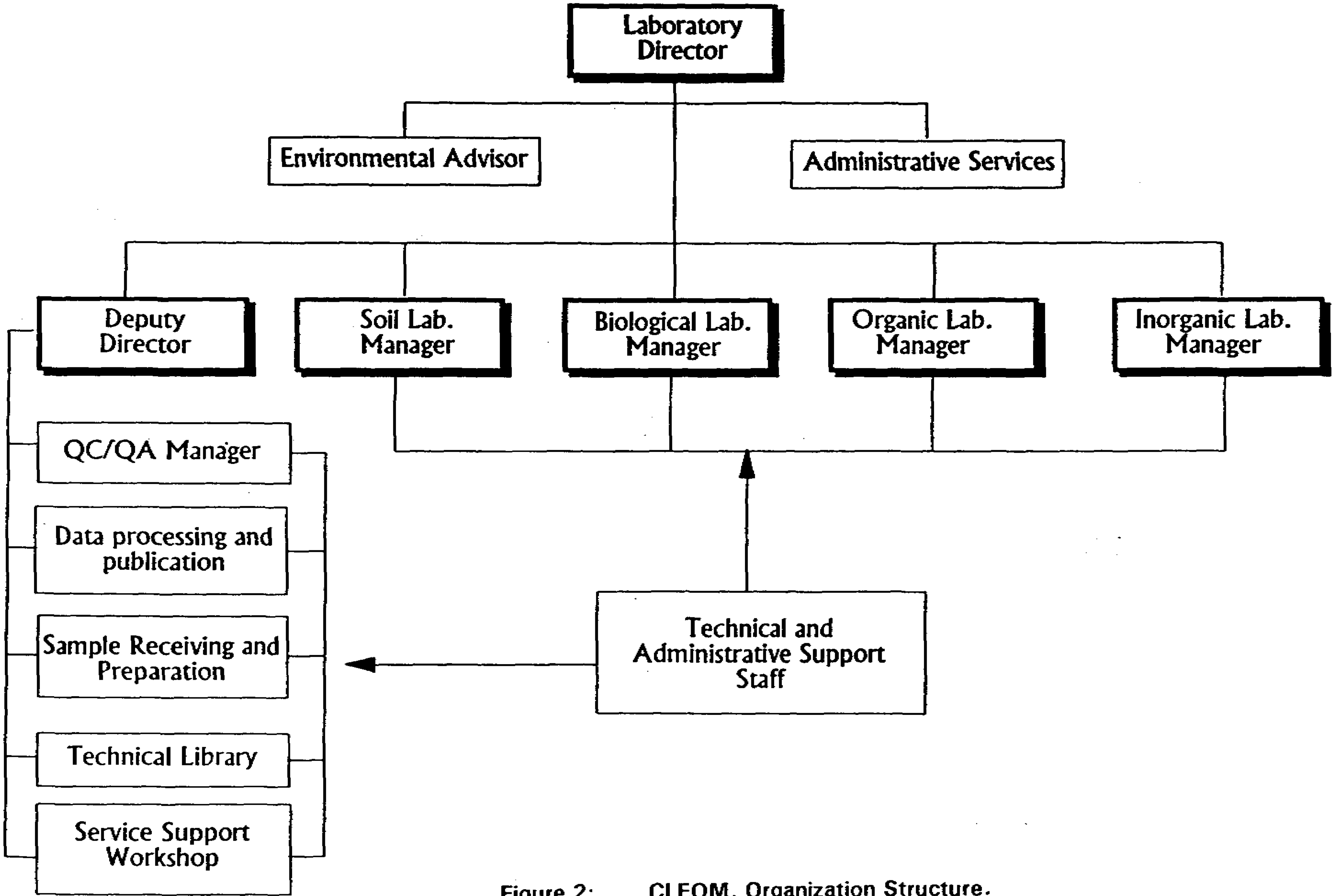

Figure 2: CLEQM, Organization Structure.

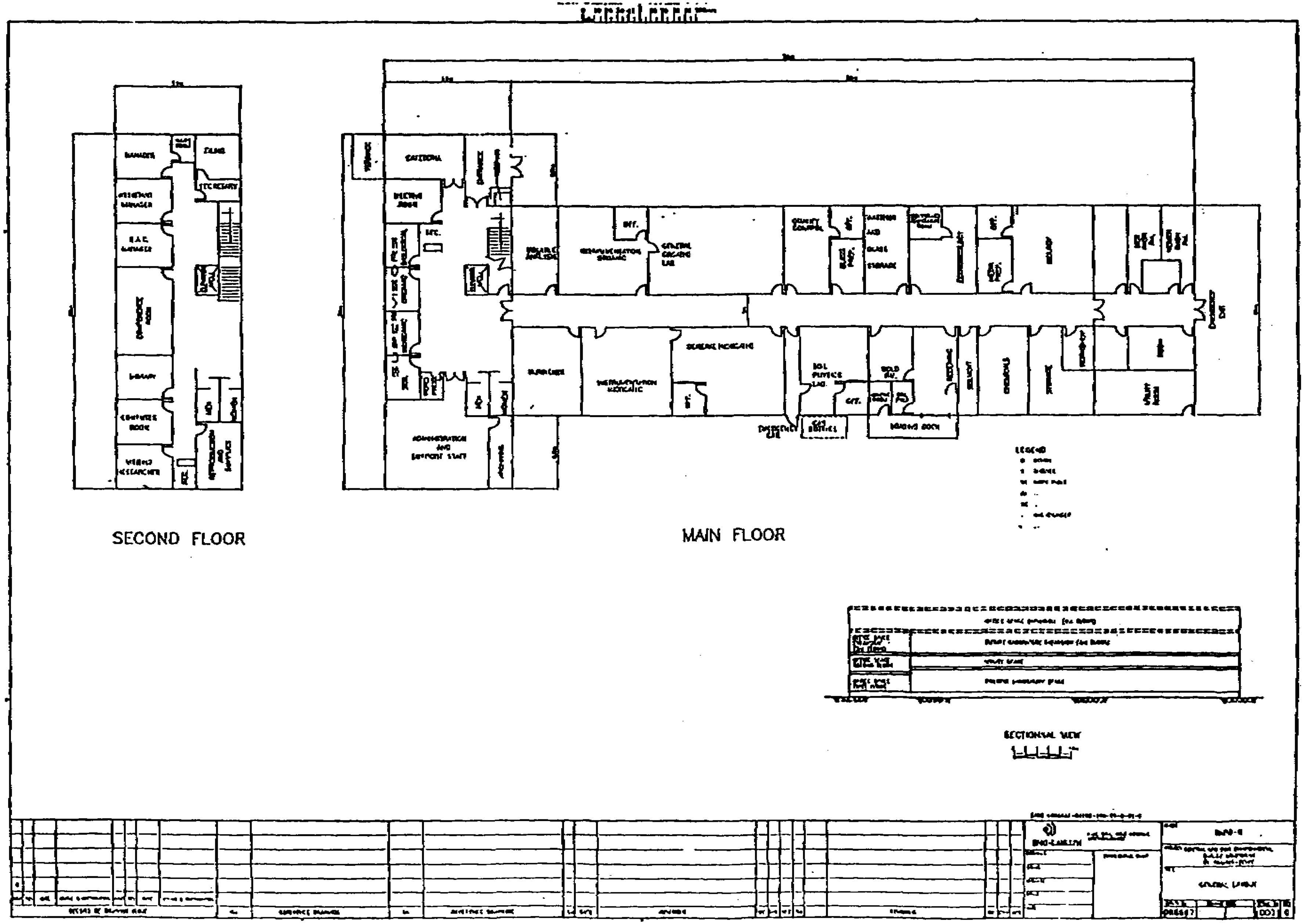

Figure 3: General Laboratory Layout .

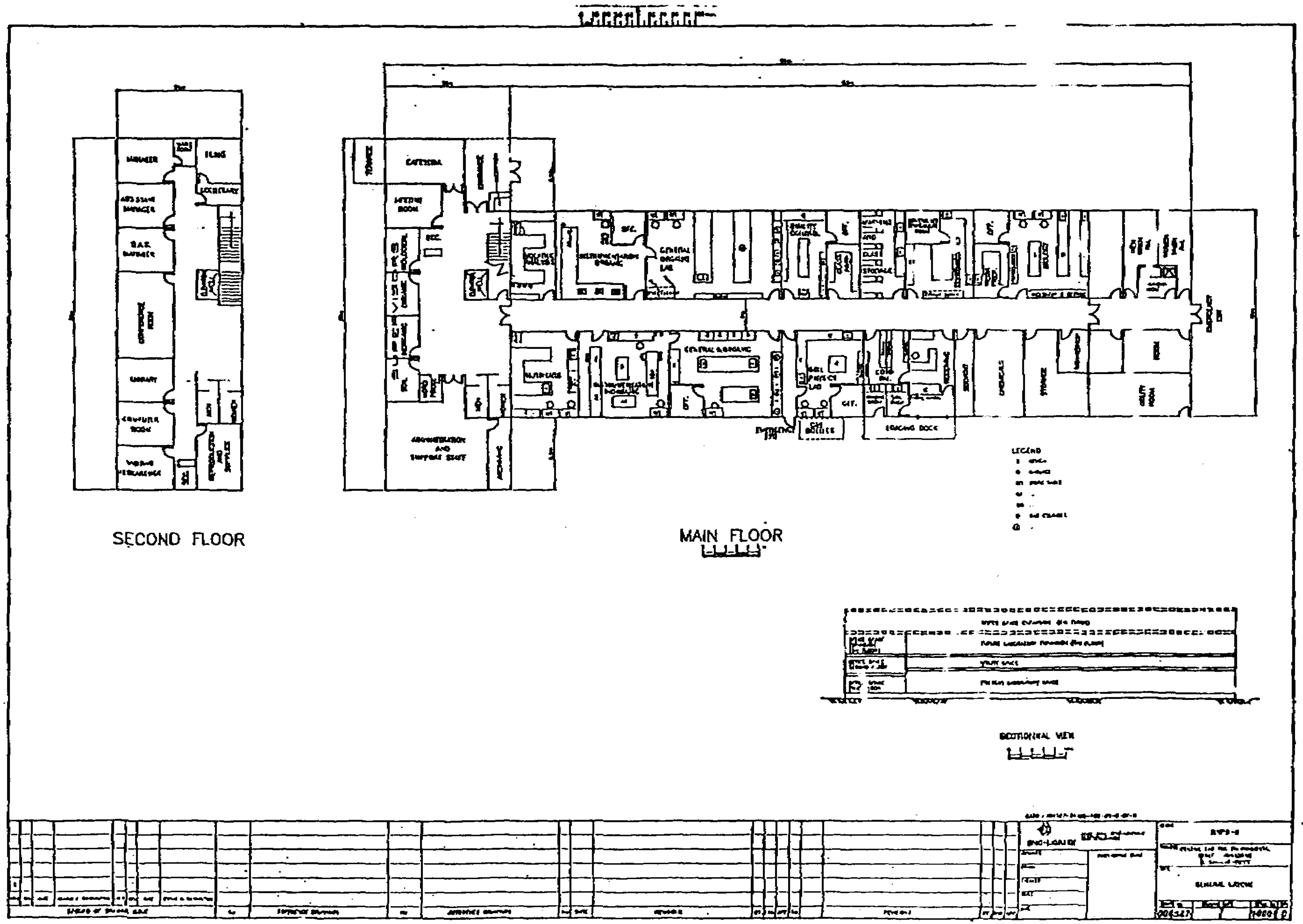

Figure 3 (cont.) General Laboratory Layout.

LA REUTILISATION DES EAUX USEES POUR L'AGRICULTURE: Appréciation de la Qualité Fertilisante des Eaux Usees Epurées Provenant d'une Station d'Epuration à Bassins de Stabilisation et Lits Bactériens Fonctionnant en Conditions Climatiques Tropicales Saheliennes

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Abstract

Wastewater irrigation of agricultural land is an olden and common practice. Considered as "resource of second hand" the treated wastewater constitutes without doubt an alternative for substitution to natural water (treated or untreated) in multipurpose. This is valid not only in arid or semi-arid areas but also in industrialised countries with tempered climate. The intentional or involuntary wastewater reuse on a large-scale is not only a natural water resource problem but also an answer to protection's worry of receiving environment across the treatment of wastewater which constitute absolute pollution factors in zone where the phreatic water sheet is shallow. To some extent, wastewater reuse generates a huge decrease of fertilizer use as amendment. This paper presents results from irrigation water after different treatment processes with the aim of assessing the fertilizing capacity of each one. This study has been undertook during peanut growing on pilot piece of land. The comparison of fertilizing quality of purified wastewater with fertilizers commonly used for this growing shows that irrigation waste water are 10 to 50 times higher than guidelines. Also, irrigation wastewater giving these results is nearly equal to minimum requirement. In view of the high cost of water supply in big cities and the increasing damage of water resources closely linked to numerous evacuation problems. One can expect the following thought: How shall we reuse water resources and take as much advantages as possible of it without deteriorating the environment?

Résumé:

La réutilisation des eaux usées à grande échelle, qu'elle soit intentionnelle ou involontaire, constitue non seulement une solution aux problèmes de raréfaction des ressources naturelles en eau mais aussi et surtout répond au souci de préservation des milieux récepteurs. Pour l'agriculture, elle devrait contribuer sans doute à diminuer de façon considérable l'utilisation des engrais comme amendements. Il ressort de la présente étude dont la période a coïncidé avec la culture de l'arachide sur les parcelles expérimentales et après comparaison faite avec les quantités d'engrais couramment utilisées pour cette culture, que les eaux usées utilisées pour l'irrigation ont des teneurs en éléments fertilisants de l'ordre de 10 à 50 fois plus élevées que ce qui est recommandé au Burkina Faso. L'importance sans cesse grandissante des coûts d'approvisonnement en eau surtout pour les grandes agglomérations, combinée aux multiples problèmes d'évacuation, font que le recyclage des ressources en eau constitue une alternative de substitution incontournable à l'eau naturelle; encore faut-il que l'environnement soit protégé.

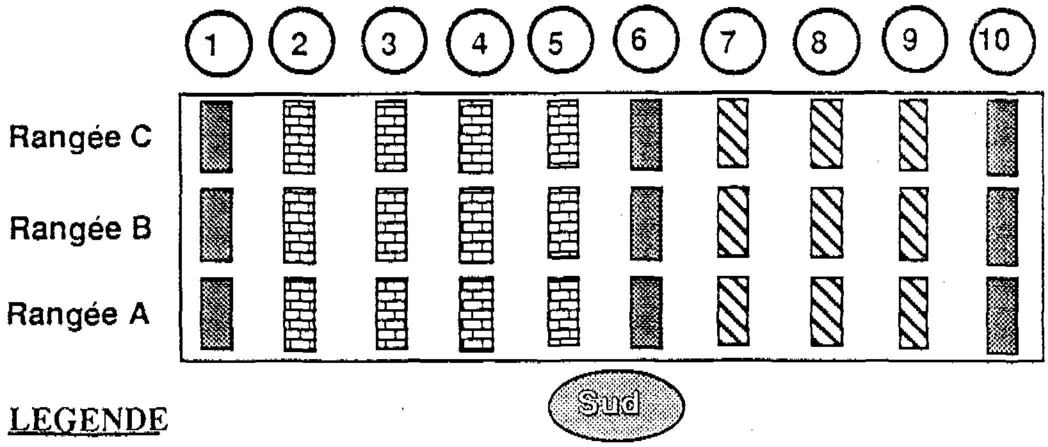
I . INTRODUCTION

Confrontée à un certain nombre d'obstacles notamment d'ordre sanitaire, technique et psychologique, la réutilisation des eaux usées englobe plusieurs domaines dont l'agriculture. Dans les pays sahéliens et pauvres, elle doit répondre aux questions prioritaires et fondamentales relatives à l'augmentation des ressources hydriques limitées d'une part, et d'autre part à l'atténuation des déficiences agricoles parfois chroniques. L'objectif de cette étude est d'apprécier la qualité fertilisante des eaux usées épurées provenant d'une station utilisant les procédés d'épuration par lagunage et lits bactériens, en vue de leur réutilisation éventuelle pour l'agriculture sur des sols situés dans la zone Sahelienne.

II. PRESENTATION DES PARCELLES

Le découpage parcellaire présente 30 parcelles de 10m x 2m chacune, classées en 3 rangées de 10 parcelles notées A, B et C. Il y existe trois types de parcelles:

Schéma du découpage parcellaire



LEGENDE

Parcelles témoin:Parcelles irriguées par les eaux du barrage de Loumbila; (Préfecture située à une vingtaine de kilomètres de Ouagadougou)

Parcelles irriguées par les eaux usées épurées provenant des filières lagunes

Parcelles irriguées par les eaux épurées provenant de la filière Lits Bactériens

III. ORIGINE DES EAUX D'IRRIGATION

La description sommaire des processus de traitement subis par les eaux avant leur utilisation pour l'irrigation permet de comprendre les différences de qualités qui apparaîtront lors de l'appréciation de leur qualité fertilisante.

Au niveau de la station d'épuration des eaux usées, l'effluent subit un dégrillage puis arrive dans une bâche de pompage dans laquelle deux pompes centrifuges immergées (de 6,4 m^3/h chacune) refoulent les eaux vers un décanteur primaire cylindro-cônique à flux vertical. Les eaux décantées sont reparties entre trois filières d'épuration: les filières I et II recevant le même débit tandis que la filière III est alimentée par un débit plus faible (20% du débit total). Les filières I et II sont constituées de deux bassins en série de forme irrégulière. Les bassins dont les berges ont une pente d'environ 45° sont réalisés avec un mélange d'argile et de ciment pour la filière I et recouverte avec une toile en polyéthylène noire pour la filière II. La filière III comprend en amont un lit bactérien de forme rectangulaire scindé en deux compartiments chargés respectivement de briques en latérite cuite et de gravier quartz. En aval, un décanteur secondaire y est aménagé. Il est suivi d'un bassin de maturation. L'ensemble des effluents des différentes filières est collecté dans un bassin de stockage d'une capacité de 20 m^3 divisé en deux compartiments contenant les eaux sortant des filières lits bactériens et celles de la filière lagune (23)

Loumbila est une préfecture située à une vingtaine de kilomètres de Ouagadougou. Les eaux du barrage de la localité sont soit utilisées directement pour l'irrigation, soit après avoir subi un traitement à travers une station de filtration lente sur sable. L'eau du barrage n'est utilisée à l'état brut que lorsque la station de filtration n'est pas en service. Le traitement de l'eau du barrage se fait à l'aide d'une unité de traitement équipée de deux préfiltres à flux horizontal en parallèle, ces préfiltres étant en série avec quatre filtres à flux vertical également en parallèle. En fonctionnement optimum, la station traite un débit de $35m^3/j$. L'eau filtrée est stockée dans une bâche. A l'aide d'une pompe centrifuge immergée, elle est refoulée vers un regard qui communique à un bassin à partir duquel l'eau est puisée pour l'arrosage des parcelles témoins.

IV. ETUDE DU SOL A IRRIGUER

L'étude des possibilités de réutilisation des eaux usées ne peut être conduite sans des connaissances préalables du type de sol recevant les effluents.

L'étude des caractéristiques physiques du sol à travers des observations sur le terrain et des analyses de laboratoire a permis de déterminer les horizons pédologiques suivants (1):

• A_1A_2 de texture sablo-limoneuse essentiellement composé de sable (67%) et très appauvri en argile (2%). Les profondeurs de cet horizon de surface occupe les 30 premiers centimètres du sol;

• les horizons A/B d'une épaisseur de 20 centimètres, B_1 d'une épaisseur de 40 centimètres et B_2 une épaisseur de 60 centimètres, tous enrichis en argile par suite de la lixiviation de l'horizon A_1A_2.

Le sol étudié est un exemple type de sol ferrugineux tropical sahélien retrouvé au Sénégal, Niger, Mali, Burkina Faso et Tchad et dans le nord de la Côte d'Ivoire (3). Sa capacité d'échange cationique extrêmement faible (T<10) et son taux de saturation élevé le situent dans la classe des Alfisols (USA) ou la classe des Luvisols (FAO). Ce sol considéré comme normal pour l'irrigation (classification de United State Department of Agriculture: USDA), présente un potentiel agricole non négligeable s'il est soumis à des amendements adéquats (labours et fertilisations). La même étude révèle en surface des teneurs relativement élevées en ions solubles, ce qui pouvait s'expliquer par l'évaporation intense accompagnée d'une remontée capillaire des sels solubles pendant la saison sèche (*DEMOLON*[56]). Ces sols présentent donc une structure compacte résultante de l'évaporation intense en saison sèche et d'une accumulation des teneurs en fer dans le profil.

V. CRITERES DE QUALITE DE L'EAU D'IRRIGATION

La période à laquelle s'est effectuée cette étude a correspondu à celle de la culture de l'arachide. Elle s'est étalée sur 12 semaines (de la mi-Avril à la première semaine du mois de Juillet). Le respect des principaux critères de qualité des eaux d'irrigation passe par la prise en compte des facteurs tels que les matières en suspension, les éléments fertilisants (N, P, K), la salinité et ratio d'adsorption , les éléments traces minéraux et la bactériologie-virologie (6). Les données recueillies portent uniquement sur les $2^{ème}$ et $3^{ème}$ facteurs ci-dessus cités.

V.1. Les Eléments fertilisants (N.P.K)

Ils font partie des éléments les plus importants et les plus influents sur le rendement cultural. En matière de réutilisation des eaux usées pour l'irrigation, leur présence en quantité suffisante combinée à leur qualité fertilisante garantissent des rendements appréciables.

V.1.1.) Apport de N.P.K,

Les quantités de matières fertilisantes apportées sur chaque parcelle dépend aussi bien de la provenance que de la quantité de l'eau d'irrigation. L'unité de mesure de cette quantité d'eau d'irrigation est un seau dont la capacité est de 18 litres. La quantité d'eau d'arrosage des parcelles correspond à 14,4mm d'eau/jour (16 seaux d'eau repartis équitablement entre le matin et le soir) ce qui fait environ 400mm pour toute la campagne soit le minimum de ce qui est recommandé pour la culture de l'arachide dont les besoins se situent entre 400 et 1200mm. Cependant, cette inquiétude est levée grâce aux quelques événements pluvieux produits durant la campagne. Le tableau ci-dessous donne en fonction des quantités d'eau reçues par jour et des teneurs respectives des éléments, les quantités de matières fertilisantes apportées en moyenne chaque jour après arrosage ainsi qu'une estimation des quantités totales reçues par les parcelles durant toute la campagne.

RESULTATS DES MESURES EFFECTUEES PENDANT LA CAMPAGNE

Date - Prélèvement	Paramètres Mesures	Conductivité (µs/cm)	Ammoniac (mg/l)	Nitrites (mg/l)	Nitrates (mg/l)	Azote total (mg/l)	Phosphore (mg/l)	Pentoxyde de Phosphore (mg/l)	Potassium (mg/l)	Calcium (mg/l)	Magnésium (mg/l)	Sodium (mg/l)	Chlorures (mg/l)	Sulfates (mg/l)
26/03/92	E PT	39	0.195	0.330	176.0		20.67	46.50		1.6	0.8		2.0	0
	E PLA	532	28.060	0.495	825.0		41.33	93.00		37.0	23.0		150.0	4300
	E PLB	520	0.000	0.413	154.0		32.00	72.00		90.0	25.0		29.0	2100
9/04/92	E PT	107	0.000	0.050	264.0		0.17	0.38	14.00	0.0	0.0	3.5	4.0	0
	E PLA	560	40.280	3.300	352.0		11.00	24.75	52.00	57.0	15.0	59.0	7.2	0
	E PLB	573	10.980	6.600	3.5		10.00	22.50	65.00	54.0	18.0	73.0	2.7	0
23/04/92	E PT	104	0.320	0.046	0.9		0.04	0.08	6.43	5.3	0.8	3.6	6.3	2
	E PLA	461	18.000	3.300	4.4		7.00	15.75	42.00	455.0	15.0	40.0	400.0	0
	E PLB	513	9.000	4.950	0.0		13.00	29.25	38.90	360.0	15.0	43.0	400.0	0
6/05/92	E PT	146	0.732	0.007	3.5		0.05	0.12	11.58	11.3	0.9	3.6	10.5	0
	E PLA	675	12.200	8.250	88.0		11.33	25.50	50.43	70.0	50.0	78.9	610.0	0
	E PLB	679	5.124	3.960	38.0		18.00	40.50	51.74	40.0	50.0	83.8	670.0	0
19/05/92	E PT	118	0.049	0.026	0.0		0.14	0.32	9.50	3.1	1.0	4.5	7.1	15
	E PLA	660	29.280	6.270	0.0		18.67	42.00	40.00	19.0	10.0	70.9	600.0	1100
	E PLB	652	31.720	5.280	0.9		26.33	59.25	40.00	27.0	9.0	72.6	670.0	600
2/06/92	E PT	133	0.310	0.033	0.4		0.63	0.14	10.70	9.2	3.8	3.7	4.6	0
	E PLA	556	23.220	3.300	0.0		3.67	8.25	18.70	10.5	54.3	57.4	360.0	100
	E PLB		28.380	3.600	0.0		7.33	16.50	16.70	111.7	54.3	51.1	270.0	0
18/06/92	E PT	139	0.037	0.165	0.4		16.67	37.50		8.8	2.8	4.0	4.0	0
	E PLA	565	36.600	2.640	8.8		9.00	20.25		24.2	5.4	9.1	28.9	47
	E PLB	570	53.680	5.940	0.0		41.67	93.75		28.3	4.6	7.5	30.8	45

L'eau de Loumbila est remplacee par celle de la Station de Filtration Lente sur Sable

Date et Lieu de Prelèvement	Parametres Mésures	Conductivite (µs/cm)	Ammoniac (mg/l)	Nitrites (mg/l)	Nitrates (mg/l)	Azote total (mg/l)	Phospore (mg/l)	Pentoxide de Phosphore (mg/l)	Potassium (mg/l)	Calcium (mg/l)	Magnésium (mg/l)	Sodium (mg/l)	Chlorures (mg/l)	Sulfates (mg/l)
1/07/92	E PT	131	0.244	0.026	1.8		0.15	0.35	11.33	11.2	3.2	3.6	15.9	19
	E PLA	327	15.860	1.650	88.0		5.00	11.25	19.13	17.1	4.2	21.8	38.6	65
	E PLB	486	10.980	2.640	8.4		6.33	14.25	29.57	22.5	4.0	46.0	74.6	0

Remarque

E PT : Eaux d'irrigation des parcelles témoin (Eaux du barrage de Loumbila)

E PLA : *Eaux d'irrigation provenant de la filière lagunes*

E PLB : Eaux d'irrigation provenant de la filière lits bacteriens

ESTIMATION DES QUANTITES D'ELEMENTS FERTILISANTS APPORTEES SUR LES PARCELLE

QUANTITES / PARAMETRES		Ammoniac			Nitrites			Nitrates			Phosphore			P2O5			Potassium		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Teneurs moyennes (en mg/l)		0.17	25.00	19.00	85.00	4.00	4.00	56.00	171.0	32.00	5.00	13.00	19.00	11.00	30.00	44.00	10.00	37.00	40.00
Quantités apportées par parcelle et par jour		0.05	7.20	5.47 5.47	24.48 24.00	1.15	1,15	16.13	49.25	9.22	1,44	3.74	5.47	3.17	8.64	12.67	2,88	10.66	11.52
Quantités apportées durant la campagne	en g/parcelle	4	648	492	2203	104	104	1452	4432	829	130	337	493	285	778	1141	259	959	1037
	en Kg/ha	2.2	324.0	246.2	1102	51.8	51.8	725.8	2216	414.7	64.8	168.5	246.2	142.6	388.8	570.2	129.6	479.5	518.4
Equivalences (en Kg/ha)		Quantités Equivalentes en Azote									Quantités Equivalentes en P2O5						Quantites de K		
		1.8	265.7	201.9				159.7	487.6	92.2	148.4	385.8	563.9	142.6	388.8	570.2	129.6	479.5	518.4

NB:

1= Eau d'irrigation provenant du barrage de Loumbila

2= Eau d'irrigation provenant de la filière lagunes

3= Eau d'irrigation provenant de la filière lits bactériens

V.1.2.) Qualité des eaux

Sur le plan de la qualité, les eaux d'irrigation des parcelles "Témoin" sont restées très pauvres en éléments azotés et phosphatés. Ce n'est qu'au début et à la fin que quelques signes de présence d'éléments phosphatés et de nitrates ont été observés. Les valeurs habituellement obtenues dépassaient rarement 1 mg/l. Seule la teneur en potassium est restée pratiquement constante sur toute la période avec une valeur moyenne de 10 mg/l.

L'observation des teneurs en pentoxide de phosphore (P_2O_5) et en phosphate (PO_4) pendant la campagne laisse apparaître que les eaux provenant de la filière lits bactériens sont plus riches que celles sortant de la filière lagunes. Il en est de même en ce qui concerne les teneurs en ammoniac mais seulement durant la seconde moitié de la période d'étude, tandis que pendant la 1ère moitié la situation inverse était observée. Quant aux nitrites et potassium, les courbes de variation des deux types d'eau usées épurées ont des allures presque identiques avec les mêmes sens de variation et pratiquement les mêmes amplitudes. Celles des teneurs en nitrates présentent des variations très irrégulières avec tout de même une teneur élevée au début de la campagne dans les eaux issues de la filière lagunes.

Les éléments fertilisants englobant les N, P, K, Ca, Mg, S, Na et les oligo-éléments jouent chacun un rôle déterminant sur le rendement cultural. Dans la sous-région et particulièrement au Burkina Faso, les engrais utilisés pour la culture de l'arachide sont par ordre de fréquence d'utilisation: le supersimple, le supertriple et le N, P, K.

Le supersimple qui est le plus utilisé, puisque recommandé par les services spécialisés en matière de culture d'arachide, servira d'élément de comparaison.Il a la composition suivante: 18% d'Azote (N), 23 à 24% de Pentoxyde de phosphore (P_2O_5), 15% de Potassium (K), 6 à 8% de Soufre (S), 1% de Bore (B) et la dose recommandée est de **100 Kg/ha** pour un rendement moyen de l'ordre de **1000 à 1500 Kg/ha** (2).

Le tableau qui suit synthétise d'une part les teneurs globales des paramètres (ammoniac, nitrates et nitrites, phosphore et pentoxyde de phosphore, potassium) en les présentant sous la forme de leurs équivalents en N, P, K, et permet d'autre part de ressortir la comparaison entre le supersimple et les eaux d'irrigation.

Fertilisants	Azote	Pentoxyde de Phosphore	Potassium
Supersimple (teneur en Kg/ha)	14	23 à 24	15
Eaux de Loumbila (teneur en Kg/ha)	161.5	291.0	126.6
Eaux de la filière Lagunes (teneur en Kg/ha)	753.2	774.6	479.5
Eaux de la filière Lits Bactériens (teneur en Kg/ha)	293.2	1134.1	518.4

Quantités de N, P, K apportées sur chaque parcelle par les eaux d'irrigation et le Supersimple

La remarque qui s'impose à l'observation de ce tableau est l'apport excédentaire d'éléments fertilisants de l'ordre de 10 à 50 fois plus que ce qui est recommandé. Dans une certaine mesure cela peut influer dans le sens positif sur la production de gousses (coque + graine) qui dépend principalement de l'apport en pentoxyde de phosphore. Selon une étude effectuée au Sénégal, un apport de l'ordre de 10 Kg/ha d'azote et 30 Kg/ha de pentoxyde de phosphore donne de bons rendements.

V.2. Salinité et Taux d'adsoption du Sodium (S.A.R.)

Tout comme le taux de matières en suspension (qui est un facteur très important pris en compte dans les études de faisabilité relatives au colmatage des sols), le S.A.R. combiné à une minéralisation élevée peut occasionner une altération de la structure du sol entraînant une réduction de sa perméabilité. Cette conséquence que l'on peut qualifier de "colmatage" physique dépend aussi des caractéristiques du sol dont la structure comme on le sait, est maintenue par les ions calcium et magnésium qu'il renferme.

En effet lorsque les eaux d'irrigation sont riches en sodium échangeable, il peut se produire une substitution de ce dernier aux ions alcalino-terreux des argiles entraînant ainsi une imperméabilisation (6). Ce phénomène est d'autant plus marquant que l'eau est minéralisée. Le risque se mesure en prenant en compte le S.A.R. de l'eau utilisée ainsi que sa salinité.

Des études menées aux Etats Unis (AYERS[54]) ont montré qu'un bon indice de caractérisation de l'alcalinité d'un sol était le taux d'adsorption du sodium (S.A.R. Sodium-Adsorption-Ratio).

Le Ratio d'adsorption du Sodium s'obtient par la relation (6):

$$S.A.R. = \frac{Na}{1/2\ (Ca + Mg)}$$

où

Na = Teneur en ion sodium exprimée en méq/l
Ca = Teneur en ion calcium exprimée en méq/l
Mg = Teneur en ion magnésium exprimée en méq/l

"L'US Salinity Laboratory" de Riverside a mis au point un diagramme qui permet de déterminer les effets de l'eau sur le sol (seulement à titre indicatif du fait que la nature du sol n'y est pas prise en compte), à partir de son S.A.R. et de sa conductivité.

Le tableau qui suit le diagramme donne les différents éléments intervenant dans la détermination de l'effet de ces eaux sur le sol ainsi que leur classification en fonction de leur provenance à partir du diagramme (6).

TABLEAU DE CLASSIFICATION DES EAUX EN FONCTION DE LEUR PROVENANCE

PROVENANCE / PARAMETRES	Eau de Loumona et de la SFLS	Eau sortant de la Filière Lagunes (Puisard P2)	Eau sortant de la Filière Lits Bactériens (Puisard P1)
Teneur moyenne en Sodium meq/l	3.79	48.13	53.36
Teneur moyenne en Calcium meq/l	5.31	35.70	31.65
Teneur moyenne en Magnesium meq/l	1.34	22.11	22.49
Conductivité moyenne	122	542	570
Sodium-Adsorption-Ratio S.A.R.	1.90	6.32	7.12
Classe	C1-S1	C2-S1	C2-S2
Qualité	Excellente	Bonne	Bonne

NB:
SFLS= Station de Filtration Lente sur Sable

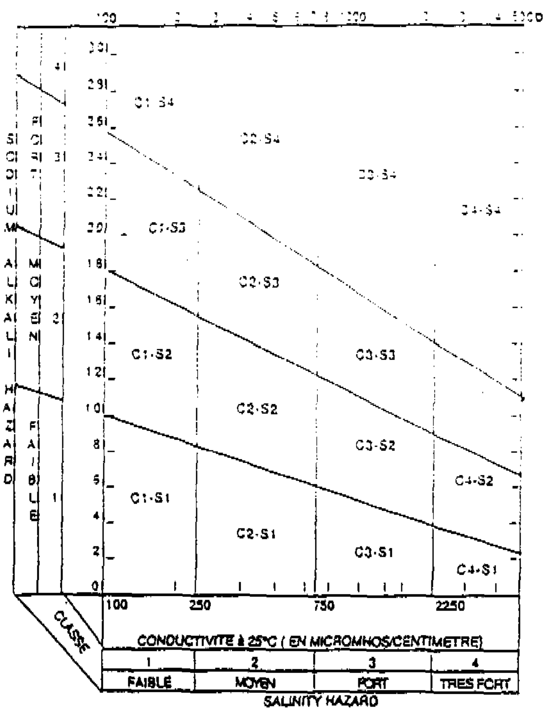


Diagramme pour la classification des eaux d'irrigation
(Manuel de l'USDA, N° 60)

La classification obtenue de ce diagramme place donc les eaux d'irrigation des parcelles Témoin dans la classe C_1-S_1 d'excellente qualité, tandis que les eaux provenant des filières lagunes et lits bactériens sont respectivement des classes C_2-S_1 et C_2-S_2.

VI. CONCLUSION

A travers cette étude, il ressort que les eaux d'irrigation des parcelles témoins se présentent comme étant utilisables sans danger pour la plus part des cultures et sur la plus part des sols.
Quant aux eaux sortant des filières lits bactériens et lagunes, elles peuvent être utilisées en général sans contrôle particulier pour l'irrigation de plantes moyennement tolérantes en sel, sur sol ayant une bonne perméabilité. Cependant des problèmes se posent quant aux plantes trop sensibles au sodium et aux sols argileux reconnus pour leur forte capacité d'échanges d'ions. Le sol, comportant les parcelles, considéré comme normal pour l'irrigation (classification de United State Department of Agriculture: USDA), présente un potentiel agricole non négligeable s'il est soumis à des amendements adéquats (labours et fertilisations). Cependant, une attention particulière doit être portée sur l'effet des excédents d'éléments minéralisants apportés par les eaux d'irrigation sur les plantes cultivées.

Les eaux usées urbaines ont une valeur qu'il faudra exploiter partout où cela est possible, en prenant en compte les mesures nécessaires pour la protection de l'environnement. Leur réutilisation présente de nombreux avantages tels que la réduction de la pollution du milieu naturel et l'accroissement de la production agricole. Cela devrait être, autant que possible, la méthode préférée d'évacuation des eaux usées et par conséquent intégrée à la planification des ressources naturelles en eau.

L'aspect bénéfique de l'apport d'eaux usées peut être beaucoup plus ressorti à travers une estimation du prix de revient de son m^3 et en le comparant aux techniques habituelles d'irrigation utilisant l'eau d'alimentation. Les avantages économiques sont à analyser aussi bien au niveau de l'utilisateur qu'au niveau de la collectivité régionale ou nationale.
Il ne faut surtout pas perdre de vue que la vulgarisation de ces techniques de réutilisation des eaux usées passe par une comparaison homogène (tenant compte de tous les éléments: mobilisation, traitement, stockage éventuel, transport, ...) entre le coût de réadaptation en qualité et d'acquisition de cette eau usée, et le coût d'approvisionnement en eau que l'on peut qualifier de primaire.

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COMPREHENSIVE ADJUSTMENT OF THE MAIN LEVELLING NETS OF THE NILE BASIN

SAFINAZ A. SOLIMAN*

ABSTRACT

During its successive meetings, the International Association of Geodesy (I.A.G), made an important decision concerning the scientific definitions of altitudes, allowing for the separation of the level surfaces (geo-potential). Each of these level surfaces can be characterized by a quantity, namely, the geopotential number. This quantity represents the work of unit mass moving in a homogeneous gravity field from the mean sea level to the surface considered. The (I.A.G.) decided that comparisons and adjustments of an international character of the main levelling nets should be made exclusively through values of the geopotential numbers. The some points of these levelling nets directly connected to maregraphs should be included in these nets, so that the relation between the positions of the different mean sea levels observed on the Nile Basin coasts can be obtained by differences. The levelling nets of the Nile Delta were readjusted according to these recommendations as a model to be adopted in the other Nile Basins. This is considered an important step for the Management of Water Resources in the Nile Basin Area.

1. Introduction

A full discussion of the errors of levelling appears in Bulletin Geodesique No.49 Annee 1936 and can be summarized as follows:-
All lines of levelling contain errors which may be classified broadly into two classes.

1- Accidental errors, which tend to obey the Gauss Law for Errors.

2- Systematic errors, which may be due to the method of work or external conditions. The tendency to one perticular sign and for the given observer working under certain conditions are likely to be of the same order of magnitude and sign over a line of several kilometres length. Different lines may show different systematic errors both in magnitude and sign. Thus a systematic error may be persistent throughout all the work or it may be accidental when considered from line to line.

In Egypt, the persistent type of systematic error, which make direct minus reverse measurements always negative, has been entirely eliminated, but as will be seen there still remains a very small accidental type of systematic error the cause of which would be difficult to discover since it behaves like an accidental error from line to line.
M. COLE has given the procedure for estimating the systematic and the accidental errors of levelling by consideration of (D-R) measurements for the different sections, the different lines and the different palygons. Investigating COLE - work was found out:

1- he did not point out to the sources of the systematic errors.

2- he did not give the magnitude and the sign of the systematic errors.

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The systematic errors on a levelling net may be due to:

1- tend to accumulate with the distance and height - differences along the levelling route.

2- tend to accumulate with the height difference, average of heights and relative positions between bench - marks along the levelling line.

Most of the systematic errors include:

1- The different attractions of the moon and sun at the center of the earth and at the observation station on the earth's surface. This is called tidal effect.

2- Variation of vertical refraction on the backsights and foresights.

3- Errors associated with the neglect of local irregularities of the earth gravity field will cause appreciable distortion in the vertical control network.

Those errors whose reliable model are achieved with reasonable degree of precision.

This paper discussion the systematic affected of the gravity on closing errors of the Egyptian first order levelling network.

2. Concept Of Vertical Positioning And Geopotential Number :

The basic of the geometric distance between any point and the staff is sight line. This line of sight is tangent to the equipotention surface indicated by the bubble in the level tube, which is a gravimetric system and affected from point to point, because the equipotential surfaces are not parallel around the earth. Figure 1.

Consider a closed loop of levelling from A to B one route and then back to A by a different route. It seems logical that the total difference in dynamic height should be zero as the starting point and finishing point are the same . However, this will not in practice, the gravity potential represents one possible way of defining a unique vertical position. If the local spacing of equipotential surfaces (levelled height difference) Δh is measured, and the value of gravity g at the same location is known, the potential difference Δw can then be evaluated .

Geopotential numbers are gaining recognition as a national measure of height for:

1- All points on a level surface have the same geopotential number.

2- The geopotential number is independent of the route taken by the line of levels used to connect the point to sea level.

The geopotential number adopted assembly of the (I.A.G.) at Rome in September 1954 is divided by the normal gravity for an arbitrary Φ 45° as:

$$HD = C/G \tag{1}$$

where C is the geopotential number , HD is the dynamic height and G is the normal gravity calculated at Φ 45°.

Orthometric heights may be derived in the same way,

$$HO = C/g' \tag{2}$$

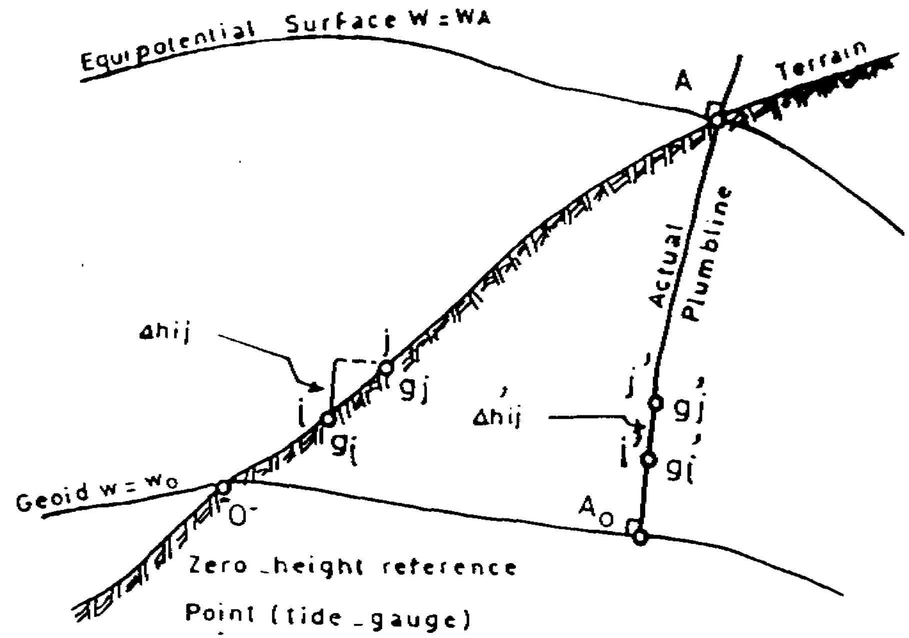


Figure 1. Geopotential Number and Equipotential Surfaces and Plumblines near the earths surface.
(After, Nassar)

where g is the mean value of gravity between the earth's surface and the mean sea level at the point of interest. More precisely, C = 0.98 H (IAG, 1954).

The actual geopotential number difference ΔC_{AB} between two points A and B, which is given by:

$$\Delta C_{AB} = C_B - C_A = \sum_{i=A}^{i=B-1} \bar{g}_{ij} \cdot \Delta h_{ij} \qquad (3)$$

where : $j = i + 1$, $\bar{g}_{ij} = (g_i + g_j)/2$ in Kgals , g_i , g_j are actual surface gravity values at i and j , Δh_{ij} is the levelled (observed) height difference between the two adjacent points i,j above mean sea level usually deduced from the levelling results before adjustment in meteres (Krakiwsky, 1965), (M.M. Nassar and P. Vanicek, 19th March 1975).

This approach is the basic concept behind the use of the geopotential numbers. We find that when observed height differences along a closed Loop ABCA:

$$\Phi\, dh \neq 0 \qquad (4)$$

$$_A\int^B dh + {}_B\int^C dh + {}_C\int^A dh \neq 0, \qquad (5)$$

It has been found necessary to apply a geopotential number for each individual levelling section due to levelling computation and adjustment.

3. System Updating Model :

Access of the demonstration of discussion here, it could be seen that the accuracy of the proposed model is relatively high comparable to historical data and the error. However, an expert system may be updated for changes in the new adjustment with the conditions of other hand. Matrix algebra of closed errors plays an effective part in advancing the techniques of the new adjustment of 'such measurements, by computing the actual geopotential numbers and then transforming them to heights by dividing by the appropriate gravity value.

The used data is obviously composed of two kind precise levelling and gravity data.

The precise levelling data was obtained from the survey of Egypt Authorities , which has been performed and edited by the precise levelling section. The actual gravity was observed at selected bench marks along the used lines from SRI, 1990.

4. Guide Lines For New Adjustments :

The new adjustment will be established in order to verify from the effect of gravity on precise levelling. The graphical display was provided to compare the accumulated orthometric correction as a systematic error with corresponding standard error on precise levelling Figure 2. Thus

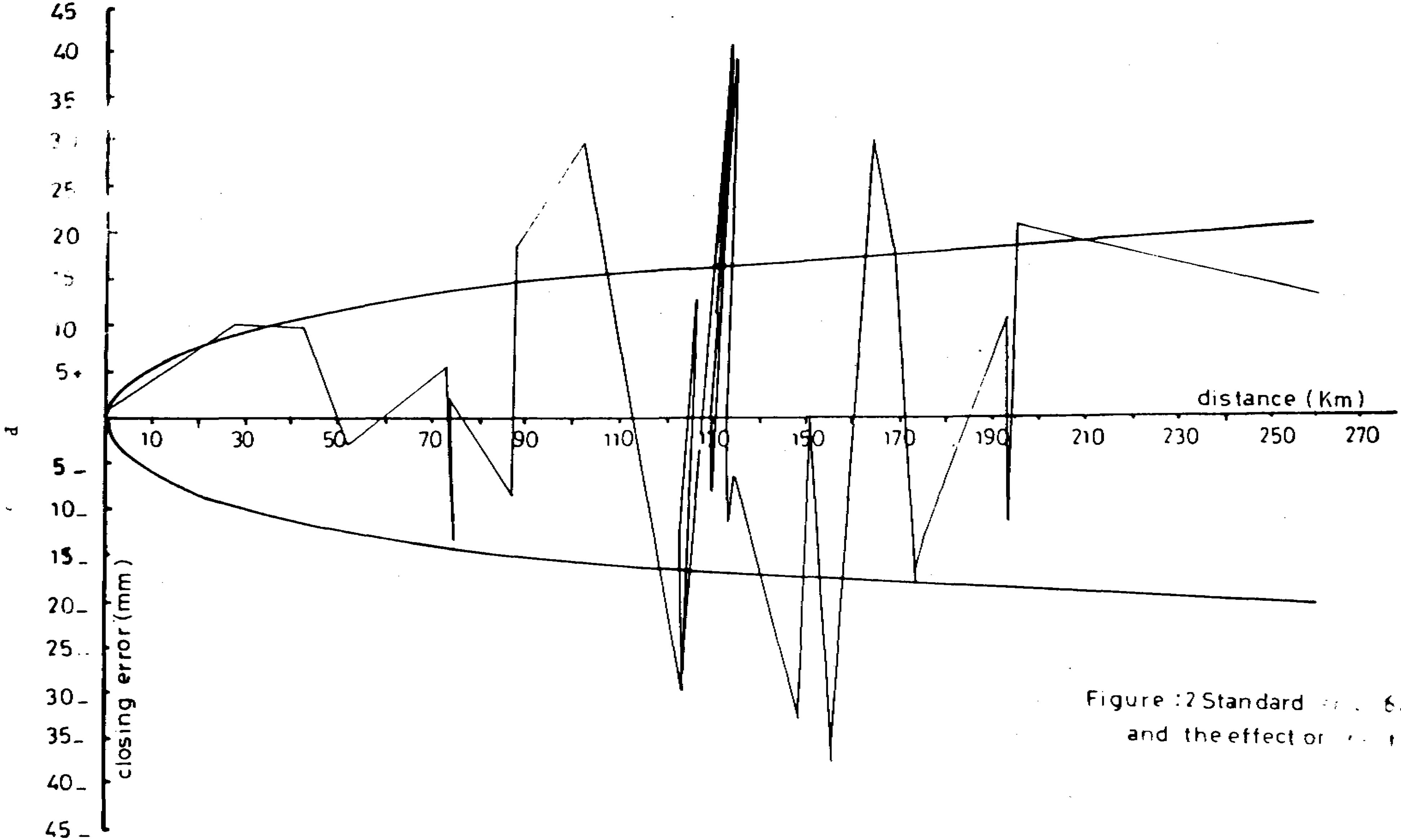


Figure :2 Standard [illegible] 67 h
and the effect of [illegible]

indicate which is the characterization expected random errors of 1.33 mm$\sqrt{Km}$. (Soliman, 1980).

It has been found that the specified value of 4mm/km corresponds to 1.5 standard deviation of that misclosure , i.e. we can write $\sigma\Delta h \cong 1.33$ mm $\sqrt{Km}$. Substituting from the statistical distribution of levelling loop misclosuress can be computed the standarized value at every lenght of the loop are shown in Table 1. The adjustment for 32 loops by 87 lines in Lower Egypt Map 1, will be given on the possibility of using the F vector which is the vector of closing error for 32 loops computed. Thus, may be written more concisely as:

$$V = Q \,.\, A^t . K \qquad (6)$$

where :

V is the vector of correction in line, dimensions 87 x 1
Q is the weight matrix, diemsions 87 x 87
A^t is the coefficient matrix, dimensions 87 x 32
K may be solved as:

$$K = (A.Q.A^t)^{-1} \,.\, F \qquad (7)$$

where :

F is the vector of closing error of Loop, dimensions 32x1

The estimate O_0^2 of the reference varience may be computed from adjustment using the relationship:

$$O_0^2 = (V^t \,.\, 1/Q.V)/(87 \text{ lines-}32 \text{ Loops}) \qquad (8)$$

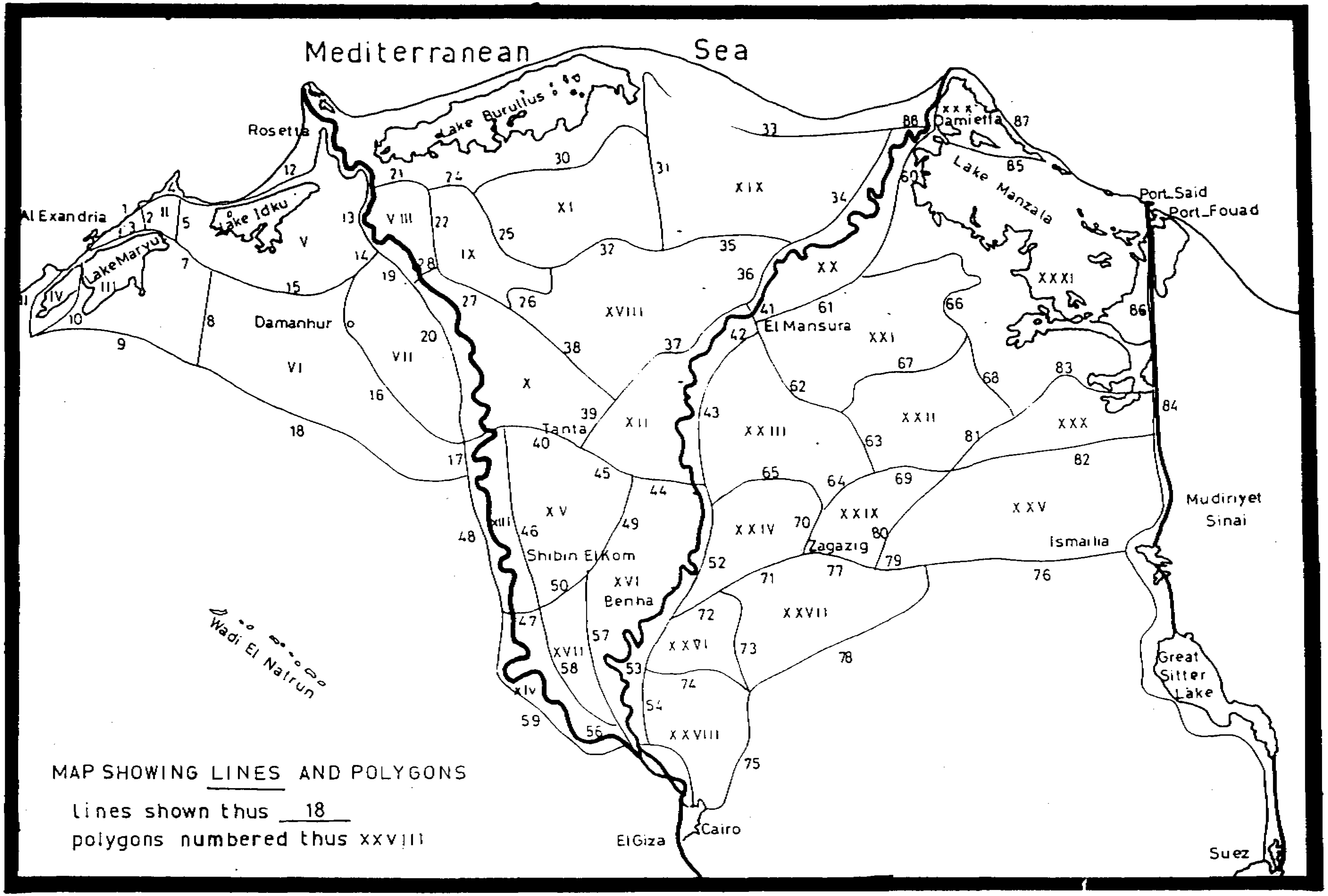
The adjustment of methods I are shown in table 2 (the residual applied of lines as: V (No. of line) = the residual (mm).

The new trial adjustment method II for the same loops and the same lines, will be given on the possibility of using the new formation of the F vector, after the possibility of using the computed geopotential number value from Equation (3). The corresponding results are shown in Table 3. The geopotential number at every line as obtained from the levelled height differences and enroute gravity values can be used as a natural measure of heights. The adjustment of method II with new F vector (closing error) for 32 loops. It can be seen from Table 4, that the method II is an optimal technique for a natural measure of heights in Egypt .

5. Discussion Of Obtained Results :

The adjusted method in 1939 (method I) of the networks in Egypt found out that the probable error was ± 2.9 mm/km without the effect of gravity. This fact was the basic motivation behind the study. The possibility of using the computed gravity corrections was limited of 0.14 mm/km from implication performed (Soliman, 1980), which is the characterization of expected random errors of $\sigma\Delta h \cong 1.33$ mm$\sqrt{km}$.

The obtained results by model (will use the geopotential number as a natural measure of heights) indicated that sigma-nout is 0.901 at method II, which is smaller than 2.404 at method I.



Mediterranean Sea
Rosetta
Lake Burullus
Al Exandria
Lake Idku
Lake Maryut
Damanhur
Tanta
El Mansura
Damietta
Lake Manzala
Port Said
Port Fouad
Shibin El Kom
Benha
Zagazig
Ismailia
Mudiriyet Sinai
Great Bitter Lake
Wadi El Natrun
El Giza
Cairo
Suez
MAP SHOWING LINES AND POLYGONS
lines shown thus 18
polygons numbered thus XXVIII

Table 1: The standarized of closing errors at every loop

No.of Loop	Length L.of Loop (Km)	Closing errors (mm) method I	The Value of error 0.14/km (mm)	Standarized Δh=1.33√Km (mm)
1	29.2	+10.0	4.088	7.187
2	44.3	+9.7	6.202	8.852
3	123.0	-16.0	17.220	14.750
4	51.0	-3.4	7.140	9.498
5	135.2	-5.7	18.928	15.465
6	193.8	+22.2	27.132	18.515
7	132.2	+11.2	18.508	15.297
8	73.8	+2.5	10.332	11.426
9	122.9	-28.5	17.206	14.745
10	134.9	-1.7	18.886	15.447
11	163.1	+30.5	22.834	16.985
12	128.2	+42.0	17.948	17.953
13	124.9	+13.9	17.486	14.864
14	110.3	+29.1	15.442	13.968
15	136.4	-11.9	19.096	15.533
16	157.9	-36.5	22.106	16.713
17	75.9	-13.4	10.626	11.587
18	165.2	+18.2	23.128	17.0945
19	194.5	-11.5	27.230	18.549
20	151.1	+0.1	21.154	16.343
21	174.3	-19.2	24.402	17.544
22	129.5	-7.4	18.130	15.135
23	123.4	-9.4	17.276	14.750
24	124.4	-3.1	17.416	18.810
25	193.0	+11.2	27.020	18.479
26	88.0	-8.6	12.320	12.477
27	123.9	-28.8	17.346	15.332
28	101.8	+28.6	14.252	13.419
29	86.2	+18.9	12.068	12.334
30	147.1	-31.4	20.594	16.125
31	260.2	+14.5	36.428	21.446
32	73.4	+6.2	10.276	11.363

Table 2. Adjustment of Method I.

The residual applied of lines as: V (NO.of line) = the residual (mm), Sigma-nout = 2.4044		
V (1)= 2.9766	V (2)= .6821	V (3)= 5.7934
V (4)= .5042	V (5)= 3.2446	V (6)= 3.1928
V (7)= .5326	V (8)= 4.4908	V (9)=-10.7795
V (10)= 8.0453	V (11)= 2.9430	V (12)=-10.3949
V (13)= 2.5022E-02	V (14)=- 1.0161	V (15)=- 2.7771
V (16)= 3.5473	V (17)=- 1.1361	V (18)= 2.9519
V (19)= .7515	V (20)= 7.3311	V (21)=- 4.6449
V (22)= 4.0632	V (23)= .2506	V (24)=- 5.1502
V (25)=-15.1639	V (26)=- 4.7201	V (27)=- 1.7211
V (31)= 1.4579	V (29)= .7880	V (30)= 6.8104
V (34)=- 5.3014	V (32)=-26.2953	V (33)=- 1.5263
V (37)= 4.7814	V (35)= 1.4016	V (36)= 13.3671
V (40)= .5745	V (38)=- 6.9271	V (39)= 3.5421
V (43)= 11.2067	V (41)= 1.3662	V (42)= 20.2985
V (46)=- 3.1386	V (44)= 3.5421	V (45)= 3.5421
V (49)= 3.5421	V (47)=- 4.2892	V (48)= 3.5421
V (52)= 1.0412	V (50)=- .2787	V (51)= 2.3565
V (55)=- 3.6007	V (58)=- 3.7535	V (54)=- .6601
V (58)= 6.0971	V (56)=-15.2294	V (57)= 3.8680
V (61)= 6.1159	V (59)= 10.2332	V (60)=-19.7022
V (64)= 5.2323	V (62)= 3.7156	V (63)= .4868
V (67)= 6.6522	V (65)=- 5.1898	V (66)=-13.1979
V (70)= 4.5934	V (68)= 5.5696	V (69)=- 1.1601
V (73)=- 7.7694	V (71)=- .1706	V (72)= 6.0691
V (76)= 2.9622	V (74)=-13.2376	V (75)=- 7.3034
V (79)= 12.9780	V (77)=-38.2198	V (78)=- 7.8584
V (82)= 12.9986	V (80)=- 9.2493	V (81)=-28.9507
V (85)=- 7.3808	V (83)=- 5.9631	V (84)= 1.0902
	V (86)= 7.3443	V (87)=- 3.6070

Table 3 : The Geopotential number

No. Li.	Δh_{ij}	$\bar{g}_{ij}979$	ΔC_{ij}	No. Li.	Δh_{ij}	$\bar{g}_{ij}979$	ΔC_{ij}
1	-2.3040	432.340	-2257297.7	45	-4.1831	350.280	-4096720.2
2	-2.2810	438.600	-2236156.3	46	+1.0517	370.697	+1030004.2
3	+4.5860	433.411	+4491681.6	47	+1.8234	347.813	+1785742.8
4	-6.0901	434.535	-5964854.2	48	-1.7050	352.785	-1669796.5
5	+3.7008	424.965	+3624655.9	49	-0.8815	348.055	-0863295.3
6	+0.1159	429.031	+0113515.7	50	-0.3609	349.465	-0353447.2
7	-0.0170	426.775	-0016650.3	51	+1.6996	361.125	+1664522.2
8	-3.4480	421.082	-3377043.9	52	+2.5884	353.965	+2534959.8
9	+10.3286	413.150	+10115966	53	-1.9310	350.335	-1891125.5
10	-7.1528	432.345	-7005683.7	54	+3.2110	335.903	+3144647.6
11	+7.1494	432.345	+7002353.7	55	+2.0168	325.237	+1975103.1
12	+3.2043	447.885	+3138444.9	56	-4.8258	341.769	-4726107.5
13	+1.5419	446.760	+1510208.9	57	-4.2125	351.565	-4125518.4
14	-0.6664	426.315	-0652689.7	58	+4.5734	349.920	+4478958.9
15	-0.3960	429.250	-0387853.9	59	-7.5758	339.662	-7419281.4
16	+5.3970	396.200	+5285801.3	60	-1.0054	448.475	-0984737.5
17	+2.8710	363.413	+2811752.4	61	+5.4950	417.710	+5381900.3
18	-12.112	382.382	-11862279	62	+6.1210	391.715	+5994856.7
19	+1.0391	430.135	+1017725.8	63	-6.6055	374.565	-6469258.7
20	+3.6915	400.020	+3615455.0	64	-0.2551	358.835	-0249834.4
21	-1.6639	426.450	-1629667.6	65	+3.9607	361.110	+3878955.5
22	+6.2773	411.315	+6148058.6	66	-0.6345	414.545	-0621438.5
23	-2.0324	432.480	-19908598.6	67	+13.410	397.875	+13133725
24	+0.6612	426.450	+0647596.8	68	+0.0020	395.075	+0001958.8
25	+4.1432	446.762	+4058043.8	69	+4.2358	355.570	+4148354.0
26	-1.3410	426.315	-1313410.7	70	+2.5251	365.855	+2472996.7
27	+2.8139	428.661	+2756014.3	71	+1.2010	361.471	+1176213.1
28	----------	----------	-----------	72	-2.8230	350.580	-2764706.7
29	-1.7009	381.315	-1665829.9	73	+5.2008	341.670	+5093360.2
30	-0.7001	459.580	-0685719.7	74	-0.4494	341.425	-0440116.0
31	+1.6704	438.665	+1636054.3	75	+2.7616	324.478	+2704502.5
32	+3.1729	425.845	+3107620.2	76	+7.5144	374.800	+7359413.9
33	-0.3026	463.485	-0296385.7	77	+0.7820	368.400	+0765866.1
34	+2.7690	446.020	+2712086.4	78	+5.9090	349.800	+5786978.0
35	-0.7960	421.200	-0779619.3	79	-1.2824	368.401	-1255942.0
36	+3.3915	413.881	+3321682.2	80	-5.7206	361.390	-5602534.8
37	+0.0562	400.665	+0055042.4	81	-2.6670	371.775	-2611690.7
38	-2.4118	408.455	-2362137.3	82	-0.5007	367.790	-0489879.7
39	+1.8731	374.565	+1834466.4	83	+1.2411	387.970	+1215528.2
40	+1.8890	463.565	+1850206.7	84	+0.8940	383.985	+0875569.3
41	+0.0354	408.135	+0034671.1	85	+2.3506	459.775	+2302318.1
42	+1.1595	399.185	+1135613.3	86	+1.9680	418.740	+1927496.1
43	+1.6215	375.985	+1588058.2	87	-2.3444	459.775	-2296245.5
44	+3.2960	353.555	+3227949.3	88	+1.7063	471.040	+1671271.4

Table 4. Adjustment of Method II.

The residual applied of lines as:
V(No. of line)= the residual (mm), Sigma nout = 0.90112

V (1) = 0.8594	V (2)= 0.0693	V (3)= 5.0888
V (4) = 0.3989	V (5)= 1.1626	V (6)= 1.5234
V (7) =- .5319	V (8)=-4.1234	V (9)=- 3.1122
V (10) =-2.6669	V (11)=-1.2658	V (12)=- 6.5207
V (13) =-3.4807	V (14)=-0.1250	V (15)=- .2783
V (16) =-3.8236	V (17)= 0.6258	V (18)=- 2.8053
V (19) = 1.6133	V (20)= 5.1666	V (21)= 7.9642
V (22) = 2.5137	V (23)= 4.2041E-2	V (24)=- .4675
V (25) =-2.5052	V (26)=-2.7154	V (27)=- 0.8400
V (31) =-0.1700	V (29)=-0.1634	V (30)= 2.8668
V (34) =-3.7703	V (32)= 8.2777	V (33)= 2.4120
V (37) = 2.8423	V (35)= 0.7560	V (36)= 2.3089
V (40) = .1252	V (38)=-2.5417	V (39)= 3.5421
V (43) = 6.5726	V (41)= 1.1974	V (42)=- .4781
V (46) =-2.0880	V (44)= 2.8421	V (45)= 3.8424
V (49) = 3.5421	V (47)= 2.6792	V (48)= 3.5021
V (52) =-1.5157	V (50)=-0.5506	V (51)=- 9.7053
V (55) =-2.0722	V (53)=-2.7566	V (54)=- .2101
V (58) = 3.0272	V (56)=-4.8491	V (57)= 2.1463
V (61) = 1.4791	V (59)= 6.2137	V (60)= 4.9043
V (64) = 3.0028	V (62)= 0.1944	V (63)=- 3.5712
V (67) =-3.6836	V (65)=-5.5620	V (66)= 2.1179
V (70) = 3.0794	V (68)= 4.3128	V (69)=- 0.4696
V (73) =-4.0865	V (71)= 0.9825	V (72)= 4.3833
V (76) = 2.9318	V (74)= 3.9982	V (75)= 7.6445
V (79) = 2.0049	V (77)= 3.9982	V (78)=- 1.2895
V (82) =-8.7830	V (80)= 4.5350	V (81)= 1.7112
V (85) =-2.7036	V (83)=-9.0871	V (84)=- .6198
	V (86)= 3.0827	V (87)= 3.1947

Compared to the old adjustment, it will be used as the new method for adjustment to create a winning proposal.

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GREY CORRELATION ANALYSIS BETWEEN INCIDENCE OF LIVER CANCER AND DRINKING WATER QUALITY IN EASTERN-SOUTH COASTAL AREAS OF CHINA

Gong Huili and Ni Fuquan[1]

ABSTRACT

Based on the grey correlation analysis between incidence of liver cancer in high occurred district and drinking water quality in FuJian, JiangSu, GuangXi, considering the basic featurs of the original environment and the secondary environment in study area, the author draw conclusions as follows:

Many factors are related with liver cancer, the drinking water isn't only one of the important factors; the concents of human body necessity components in drinking water in liver cancer high occurred district in eastern-south coastal areas of China, such as, Ca^{2+}, Mg^{2+}, Mo, Zn, etc., are lower: Ca^{2+} of magnanimous components, as well as Cu of the trace components, NO_3^- of the pollution index etc. factors are higher related with the incidence of liver cancer.

INTRODUCTION

In some disease areas, when study on the relationship between drinking water quality and the incidence of a locity disease, in order to find and study the principal factors, which control the drinking water quality in disease district, usually adapt methods that belong to the old correlation analysis, such as, step by step regression analysis, principal component analysis etc. But, drinking water quality system is such system as information isn't completely definite, the relationships among factors which affect the incidence of liver cancer are not completely definite yet. So, this is a grey system, the grey system theory should be used to deal with it's inner rules.

THEORY AND CALCULATION

Grey correlation analysis is such a system theory method as study relationships among factors based on the similitary or difference. Usually use the grey correlativity to express the affect degrees among factors. The bigger the correlativity is, the more serious is the affected degree, thus indicate that this factor is highly related with another factor.

Suppose there is one original data matrix of affected factors as follows:

$$x_{ij} = \begin{vmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{vmatrix} \quad (1)$$

Where, x_{ij} is the content of the J index in I sample, n is the number of samples, m is the number of index.

Standard the original data matrix as follows:

$$X_i(k) = \frac{x_i(k)}{x_i(1)} \quad (2)$$

Where, $i=1,2,\ldots n$; $k=1,2,\ldots m$.

Calculate the absolute value of difference between mother-factor and son-factor as follows:

$$d_i(K) = |X0(k) - Xi(k)| \quad (3)$$

Where, $X_0(k)$ and $X_i(k)$ are respectively the original data of mother-factor, the original data of son-factor; $d_i(k)$ is the absolute value of difference between mother-factor and son-factor.

Calculate the biggest difference and the smallest difference between the two grades:

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$$\Delta min = min(i)min(k)(d_i(k))$$

(4)

$$\Delta max = max(i)max(k)(d_i(k))$$

Where, Δmin is the smallest data among the smaller data; Δmax is the biggest data among the bigger data. Namely, in the condition of firstly fix i, choose the smaller (or the bigger) value among the data of $d_i(k)$, then choose the smallest (or the biggest) value among them.

Calculate the correlation coefficition as follows:

$$L_i(k) = \frac{\Delta min + C \times \Delta max}{d_i(k) + C \times \Delta max} \qquad (5)$$

Where, C is constant (in this paper C is 0.5), $L_i(k)$ is the correlation coefficient. The meaning of other symbols are given before.

Calculate the correlation degree:

$$R_i = \frac{1}{m} \sum_{k=1}^{m} L_i(k) \qquad (6)$$

Where, R_i is the correlation degrees. The meaning of other symbols are given before.

CASE

Liver cancer is unevenly distributed in China. The high occurred area mainly lies in the eastern-south coastal areas, such as GuangXi FuSu, JiangSu QiDong, ZheJiang TaiShan, ShangHai etc. areas. The incidence of liver cancer are respectively 48.83×10^{-5}, 47.93×10^{-5}, 36.5×10^{-5}, 21.17×10^{-5}. With respect to the cause of liver cancer, the "water and soil" doctrine hold as follows: the content of the trace elements, such as, Mo, Se, Cu, Zn etc. in the water and soil in disease district is lower, and yet, the content of NO_3^-, NH_4^+ is higher. Moreover, from the point of biology function of the element, Ca^{2+}, Mg^{2+}, Mo, Se, Cu, Ge, Zn etc. are related with cancer closely. The pollution of the drinking water quality shouldn't be neglected, especailly, when the content of NO_3^-, NH_4^+, the phenol, COD, humic-acid in drinking water is higher. Based on this point, Ca^{2+}, Mg^{2+}, Mo, Ba, Cu, Zn, NO_3^-, NH_4^+, COD, humic-acid in drinking water have been chosen as factors to participate in grey correlation analysis with the incidence of liver cancer.

The Original Data

The test index in water quality in ChangPing country, QuLi country, Young pool water etc. in FuSui of GuangXi are Ca^{2+}, Mg^{2+}, Mo, Cu, Zn etc. 5 items, see table 1. The test index in house trench water, vanish trench water, river water and groundwater (shallow well water, deep well water) in QiDong of JiangSu are NO_3^-, COD, humic acid, see table 2. The test index in groundwater quality in ChangLe, PuTian, NingHua, FuAn etc. four counties of FuJian are Cu, Ba, NO_3^-, NH_4^+ and COD etc., see table 3. The incidence of liver cancer has also been listed in tables.

Results

The calculated results of the grey correlation analysis are given in table 4.

Discussion

From the table 4, the following conclusions are drawn:

Ca^{2+}, Mg^{2+} magnanimous forms in drinking water in FuSui of GuangXi combining with other affecting factors are higher related with the incidence of liver cancer, the correlation degrees are respectively 0.708, 0.523; trace forms, such as Mo, Zn combining with other affected factors are higher related with the

TABLE 1. Water Quality Table in High Occurred District of Liver Cancer in FuSui

Test Items	Units	Chang Ping 1	Qu Li 1	Young pool	Chang Ping 2	Qu Li 2	Wu Ming
Ca^{2+}	mg/l	37.66	69.56	58.43	36.39	11.88	19.40
Mg^{2+}		2.81	7.31	19.64	3.39	5.03	1.88
Zn		43.0	47.0	47.0	53.0	43.0	40.0
Cu	μg/l	5.0	7.0	7.0	7.0	8.5	6.5
Mo		1.19	0.01	0.81	0.17	0.9	0.6
Incidence of liver cancer ($\times10^{-5}$)	no	112.2	102.1	101.1	88.1	88.9	83.0

TABLE 2. Water Quality Table
in QiDong of JiangSu

Test Items	Units	House trench water	Vanish trench water	River water	Shallow well water	Deep well water
NO_2^-		0.535	0.48	0.376	0.218	0.047
COD	mg/l	4.66	3.85	3.55	3.204	1.29
Humic-acid		0.434	0.36	0.284	0.184	0.08
Incidence of liver cancer ($\times 10^{-5}$)	no	65.53	58.17	41.99	5.42	0.00

TABLE 3. Water Quality Table
in ChangLe of FuJian

Test Items	Units	ChangLe	PuTian	Ning Hua	Fu An
NO_2^-		0.166	0.213	0.020	0.011
COD	mg/l	2.40	2.73	1.64	1.84
NH_4^+		0.413	0.532	0.051	0.072
Cu		6.51	4.95	3.82	5.09
Ba	μg/l	35.29	158.23	43.43	72.71
Incidence of liver cancer ($\times 10^{-5}$)	no	28.89	32.85	10.44	12.09

TABLE 4. Correlation Degrees Table
of the Incidence of Liver Cancer and the Components
in High Occur District in Eastern-south Coastal Areas of China

Test Items	Units	FuSui in Guangxi	Qi Dong in JiangSu	ChangLe etc. four counties in FuJian
Ca^{2+}	mg/l	0.708		
Mg^{2+}		0.523		
Zn		0.521		
Cu	μg/l	0.377		0.880
Mo		0.586		
Ba				0.624
NO_2^-			0.811	0.747
COD	mg/l		0.680	0.791
NH_4^+				0.767
Humic-acid			0.777	

incidence of liver cancer, the correlation degrees are respectively 0.556, 0.521.

Pollution index, such as humic-acid, COD, NO_2^- in drinking water quality in QiDong of JiangSu is obviously related with the incidence of liver cancer, the correlation degrees are respectively 0.777, 0.680, 0.811.

Cu, Ba, these two trace forms of test index in drinking water in ChangLi etc. four counties of FuJian are obviously related with the incidence of liver cancer, the correlation degrees are respectively 0.880, 0.624; pollution index, such as COD, NH_4^+, NO_2^- are obviously related with the incidence of liver cancer, the correlation degrees are respectively 0.791, 0.767, 0.747. Cu this trace form is very special, it's correlation degree is the biggest value in FuJian, amounts to 0.880; on the contrary, it is only 0.377 in GuangXi, which is the smallest value in all correlation degrees. All these conclusions show that: the factors, which affected the incidence of liver cancer are many constitute factors, even in the water environment, there is no exception.

All above results show that, the affection of characteristics of different drinking water in the different areas for liver cancer aren't the same, so should be analysized conditionally:

From the point of environmental hydrogeological characteristics, in the disease district in FuSui of GuangXi outcropping strata are respectively as follows: grey-white thick strata, massive limestone accompanied by dolostone, oolitic limestone and bioclastic limestone lie in ChangPing; grey-white thick-bedded massive limestone, dolomitic limestone lie in QuLi. Because of lacking water, the local inhabitants mainly drink bad quality pool water or well water which leak from the pool, and also, the climate type is the moist-hot, limestone mother material soil develop into red soil which contain a little of carbonate, actually, in this environment various magnanimous, trace forms, such as Ca^{2+}, Mg^{2+}, Zn, Cu, Mo etc. are very deficieny, see table 5.

Alluviem, silting, littoral deposit and continental-oceanic interacting strata lie in QiDong disease district of JiangSu the content of humus in soil is higher, mainly belong to reduction environment. There is methane in the march and beside the pool. CH_4 is the mainly material in this environment. The value of pollution material of industry and living, such as NO_2^-, NH_4^+, COD in the drinking water is higher. Both harmful and noxious material mainly lie in the river water, ditch water, shallow loose rook type ground water, especially lie in the ground water of Quaternary period marine-deposition strata in ChangLe etc. four counties of FuJian. The flattish relief lies in this district, so the flow of the groundwater is very slow, the ability of flow and self-purificition of the pollution material is very limited. This environment is closely related with coastal deposit. Bedrock lying in the district where liver cancer high occur, are granite and ash tuff. The content of Ba in water in this district is higher.

To sum up, based on the forming of the original environment and affected by the secondary environment, liver cancer high occurred environment has been evolved, the former include the condition of geomorphology, geology and geochemistry; the latter's manifestation is the situation of transforming and utilization by human beings. The liver cancer district affected by many factors and many administrative levels, which interact among them. Whether the content of Ca^{2+}, Mg^{2+}, Zn, Cu, Mo, Ba in the drinking water is higher or lower can affect incidence of liver cancer and bring out different cancer and tumour, the pollution of the drinking water quality shouldn't be neglected yet, especially, NO_2^-, NH_4^+ etc. items. Experiment shows that NO_2^- combining with the phenol easily evolved nitroso compound. When the drinking water contains higher organic material or when COD value of the drinking water is higher, the nitroso varies easily, this change has a positive affection on the formation of nitroso compound as well as accelerated developing and growing the

TABLE 5. Lower Carboniferous Mother Material Soil Chemical Component (unit: mg)

Components	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	TiO_2	MnO
Contents(%)	79.8 ¦ 63.2	7.4 ¦ 15.3	4.7 ¦ 6.4	0.05 ¦ 0.82	0.1 ¦ 1.18	0.42 ¦ 1.82	2.57 ¦ 3.31	0.05 ¦ 0.10	0.38 ¦ 0.68	0.006 ¦ 0.25

cancer cell in humanbody. So, the common important cause for the liver cancer high occurred is likely of the fact that contents of NO_3^-, NH_4^+, COD, humic-acid in the drinking water are higher.

SUMMARY AND CONCLUSIONS

In endemic liver cancer high ocourred areas, the cause of liver cancer are more complicited, no unanimous conclusion can be drawn. This paper think following conclusions are well worth discussing:

Endemic liver cancer isn't absolutelly controlled by only one factor in all affected factors which synthesize acted among them, it related with the chemical form constitute in drinking water closely. It is well worth studying.

The common important cause for the liver cancer high ocourred is likely of the fact that the content of NO_3^-, NH_4^+, COD, humic-acid in the drinking water are higher. Whether the content of Ca^{2+}, Mg^{2+}, Zn, Cu, Mo, Ba and their value constitue in the drinking water is higher or lower can affect incidence of liver cancer and bring out different cancer and tumour. The grey correlation analysis, as a new kind of method, quantitativebd the relationship between incidence of liver cancer and contents of forms, but view the situation as a whole, this method still belong to qualitative analysis, so it is one kind of quantitativebd qualitative analysis. Thus provied us with one kind of system analysis method for analysizing and judging the affected factor of the endemic liver cancer.

Endemic liver cancer is related with many factors, such as living environment, living habit, even heredity, sex, age, occupation etc. of the local inhabitants.

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