Abs. Nr. PO-083

Application of GPS and GIS for Assessment of Groundwater Flow

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Coastal zones are unique. It is a place of high priority interest to people, to commerce, to the military, and to a variety of industries because it contains dense populations, undergoes great environmental modification and deterioration through landfill, dredging, and pollution caused by urban, industrial, and agricultural development. A recent assessment in Science (1997) stated that 37% of the world's population lives within 100 km of the coast. Ground water is a major source for all developmental activities, especially for resort based tourism (ICMAM Plan for Chennai). The tremendous increase in population over the coastal area leads to over exploitation of ground water resources causing salt-water intrusion problems in these areas.

When ground water resources are overexploited, more water is used than the aquifer can replenish through infiltration. Without sufficient recharge of the ground water, wells can go dry or "Pull" saltwater from the estuaries into the aquifer (John R, Clark).

Monitoring the ground water level and its quality is essential for the sustainable use of groundwater resources and to prevent saltwater intrusion into the fresh ground water. Presently, ground water levels are monitored independently without reducing to MSL (Mean Sea Level), as the process is labour intensive and expensive. With this method, spatial distribution of flow cannot be assessed. An efficient and fast method was used at Pondicherry to connect all observation wells. Pondicherry region, one of four enclaves, which constitute the Union Territory of Pondicherry (UTP), a former French Colony, is implementing project "Tank Rehabilitation Project Pondicherry" (TRPP) to improve the ground water condition. As a part of the project Real Time Kinematic GPS was used to measure the ground level from the mean sea level. The study covering an area 900 km^2 with 240 observatory wells were surveyed using RTKGPS and reduced to MSL. The collected data were processed using ArcView GIS software.

The application of RTKGPS and GIS helped in arriving at the flow condition of groundwater and spatial distribution of levels in the observation wells of Pondicherry. Based on the above study, PWD is working out strategies for identification of recharge area and policy for minimising the over exploitation of ground water among different user groups.

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Abs. Nr. PO-087

Crop Yield Maximization – Orthogonal Experiments Approach

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The population explosion in the world poses a challenge to agricultural scientists and engineers in proportionately increasing the production of cereals, pulses, vegetables and fruits despite constraints. Though several countries have made substantial progress in the green revolution in respect of self-sufficiency in the production of cereals, it is quite evident that the minimum dietary needs of a common man have not been met so far. Because of the narrow land-man ratio which would get still narrower in coming years, the only hopeful means of supplying needs of agricultural produce would be by raising the productivity level.
In order to obtain the maximum benefit, effort has to be made in the input level of the irrigation process. Hence the main parameters of the process should be set at optimal conditions to arrive at the maximum yield with certain degree of confidence. If a full factorial experiment is used, there is a minimum of 2f combinations that must be tested (f=number of factors each at two levels). In contrast to such formal designs, Taguchi Orthogonal experiment design is a more powerful analytical tool used to slash developmental time and cost and to specify more precise values for process specifications. The Orthogonal Array (OA) in the experiment has the ability to evaluate several factors for process improvement with the minimum amount of test data. If the orthogonal experiments are conducted under controlled conditions, the outcome can be quite effective, useful and efficient in leading to the rapid empirical optimization of designs.
In this paper, the design of orthogonal experiments to determine the optimal levels of the factors/interactions of an irrigation process to maximize yield is presented. The Cause-Effect diagram has been used as the comprehensive tool to identify the potential factors that might lead to performance deviations. Water, soil, fertilizer and light exposure each at two levels are the design parameters and yield from the crop- Pusa Naubahar (a variety of cluster beans) is the response considered in the study. The results obtained from the orthogonal experiments have been analyzed to subsequently achieve the optimum design. This has been confirmed from the results of the traditional full factorial experiments. Signal-to-noise ratio procedure has been proposed to have the control over the factors beyond the design parameters such as climate, humidity, pollution and other environmental changes.
The agricultural scientists, in the recent years, have recognized the need for improvement in the yield of agricultural products due to the growing population. In order to obtain maximum benefit, effort has to be made in the input level of the irrigation process. The orthogonal experiment was conducted under controlled conditions on the process of growing Cluster Bean crop, to determine the

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optimum levels of the factors/interactions to maximize yield. The best setting from the full factorial confirmation experiment revealed that results of the orthogonal experiment provide the optimal design.

Abs. Nr. PO-090

Strategies to Upkeep the Ecology of the Coastal Regions and to Attain Sustainable Groundwater Development from the Coastal Aquifers of Tamil Nadu - India

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Tamil Nadu is underlain by six geological terrains ranging in age from the recent sand dunes to the oldest crystalline rocks of Archaen age. Only 26% area of this State is covered by sedimentary formations. They are located mostly adjacent to the coast. They have appreciable quantity of groundwater. Any damage to the coastal eco-system will affect the potential aquifers of the coast and pollute the groundwater.

The low lying long coast, heavy extraction of groundwater in the sedimentary areas, favourable aquifer properties of the coastal aquifers, sea water intrusion, saline water aquaculture high tide frequent monsoon failures are the major causes deteriorating the coastal ecology of this State.

Tamil Nadu is a deficit water resources State where the present per capita per year water resource is only 805 cubic metre. Unless effective steps are taken up now to increase or save the water resources of this State, the per capital per annum water resources during 2050 AD will be about 435 cubic metre. At that point of time this State is likely to suffer even to meet the domestic demand.

Even now this State is reeling under the severe water scarcity. During 2025 AD this State needs about 2,423 tmcft of water for all the sectoral needs. But the available water resource is 1,674 tmcft. Hence, deficit is 749 tmcft, that works out to 44.74%. If action is not being taken up immediately to increase or save the water resources, the supply and demand of this State during 2050 AD will be 1,499 tmcft, that works out to 89.55%.

Out of the total groundwater potential of this State about 50 to 60% is obtained from the sedimentary aquifers located adjacent to the coast. If there is no check to arrest the coastal zone eco system deteriorating agents like, sea water intrusion and the other natural or man made activities, it is likely that the entire fresh water aquifer which are located within 80 to 100 km distance from the coast are likely to be contaminated/deteriorated within another 25 years.

While the water resources status of this state is very grim the heavy extraction of groundwater in the coastal aquifers have already started to deteriorate the fresh groundwater not only in Minjur north of Chennai but also in some other areas due to seawater ingress. In Minjur the seawater has already invaded about 16 KM

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and polluted the inland aquifer. The annual migration rate of the seawater ingress is about 427M.

Now about 17 Million cubic meter (MCM) of fresh groundwater per annum is deteriorated due to the seawater intrusion alone. If there is no check to control the seawater ingress about 40 MCM of fresh groundwater is likely to become saline per year in the 1,000 km coastal length of this State.

The authors would like to suggest the following strategies to prevent the deterioration of the eco-system of the coastal areas of this State.

1. Develop the ground water in such a way to by keeping the groundwater level in the coastal aquifers always one foot above mean sea level.
2. Carry out artificial groundwater techniques like (1) Surface spreading (2) Injection, (3) creation of fresh water ridge (4) development of pumping through (5) Construction of subsurface barrier etc.
3. Adopt all the coastal zone management approaches, including implementation of groundwater norms

The authors feel that only through these approaches would it be possible to upkeep the ecology including arresting the seawater ingress in the coastal areas of this State. Then it would be possible to get a sustainable groundwater resource from the coastal as well as in the sedimentary aquifers of the State. Since the groundwater resources of the coastal aquifers are about 60% of the total groundwater potential of this State the above strategies have to be implemented forthwith.

Abs. Nr. PO-092

Reutilization of Industrial Solid Waste for Industrial Effluent Treatment

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Industrial solid waste, Fe(III)/Cr(III) hydroxide was investigated for the adsorptive removal of phosphate from effluents. Synthetic solutions of phosphate were employed. Batch mode adsorption studies were carried out examining the various parameters such as adsorbate concentration, agitation time, adsorbent dose, pH and influence of coexisting anions. Adsorption process followed second order rate kinetics. Equilibrium adsorption data obeyed both Langmuir and Freundlich isotherms. Langmuir adsorption capacity was found to be 6.53 mg/g. maximum removal occurred at pH 4.0. Studies on pH effect and desorption showed that involving surface complex formation seems to dominate in the adsorption process.

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Abs. Nr. PO-098

Flux and Chemistry of Tannery Effluents: A Case Study of Narayani Leather Industry, Birganj, Nepal

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Effluents discharged from point sources poses one of the major threats to surface water bodies in most developing countries, where regulatory measures for containing industrial pollution is very poor. This is of important concern for Nepal which is an environmentally vulnerable country. *Narayani* Leather Industry is one of eight operating leather industries situated at *Birganj* on the bank of river *Sirsiya*, and contributing significantly to the national economy of Nepal. This paper deals with the physico-chemical properties of effluents from the leather industry and that of river water and the elemental flux from the leather industry to the river.

Samples of effluents from *Narayani* Leather Industry and that of water from *Sirsiya* river were collected during December 2002 from six stations such as the effluents at discharge points, river water at the discharge points and two samples of river water one each from upstream and down stream from the discharge point of effluents. The samples were analyzed for pH, electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), Na^+, K^+, Ca^{2+}, Mg^{2+}, S^{2-}, PO_4^{3-}, Cl^-, HCO_3^- and Cr. It has been observed that the quality and quantity of effluents (~ 96 * 10^6 Lyr^{-1} to 130 * 10^6 Lyr^{-1}) from the industry to the river *Sirsiya* is of major concern. The effluents (even after treatment) are alkaline (pH = 8.41), and characterized by high EC (7530 µS/cm), TDS (5745 mgl^{-1}), COD (1121 mgl^{-1}) with virtually no DO. The effluents also contain large quantity of SS (347 mgl^{-1}). Among the major cations Na^+ (1820 mgl^{-1}) and Ca^{2+} (68 mgl^{-1}) are very high in the effluents compared with that of river water (44 mgl^{-1} and 23 mgl^{-1} respectively). Similarly K^+ and Mg^{2+} (16 mgl^{-1} and 15 mgl^{-1} respectively) are also very high is concentration with respect to that of river water (04 mgl^{-1} and 09 mgl^{-1} respectively). The concentration of Cl^- and S^{2-} (1068 mgl^{-1} and 72 mgl^{-1} respectively) among the anions in the effluents is particularly very significant compared with that of river water (59 mgl^{-1} and 32 mgl^{-1} respectively). Phosphate concentration in the treated effluents is about ten times more than that of river water (0.04 mgl^{-1}). The most important heavy metal – chromium – in the tannery industries is about 7.27 mgl^{-1} in the treated effluents which is much higher that that in river water (1.74 mgl^{-1}). These comparisons suggest that the River *Sirsiya* is potentially active in accommodating the effluents by its dilution effect, biological consumption, and chemical neutralization by providing sinks in the clay minerals and by its inherent natural chemistry. Excellent correlation coefficients between EC and TDS (r = +0.99), pH and alkalinity (r = +0.97) and DO and COD

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(r = -0.89) also suggests that the natural system is active simultaneously with the discharge of effluents to the river.

An estimated total of ~ 294 to ~ 412 tons of elemental flux annually take place from the leather industry to the River *Sirsiya* within an operating period of 300 days in a year. The major share of the annual elemental flux is constituted by Na^{+} (~ 175 to ~ 245 tons) and Cl^{-} (~ 103 to ~ 143 tons). Calcium and S^{2-} takes the second position with ~ 7 to ~ 9 tons and ~ 7 to ~ 10 tons respectively per year. Chromium constitutes ~ 698 kg to ~ 977 kg of flux to the River *Sirsiya* from the industry annually. This significant flux of the major elements and chromium if continued for long may jeopardize the ecological processes in the river. This may render the *Sirsiya* River water unusable for domestic, industrial and even for irrigation purposes.

Abs. Nr. PO-114

Urban Pollution and its Impacts on the Surface and Adjacent Groundwaters of Adyar River Basin

A. Nirmal Rajkumar[1], B. Senthil kumar[1], S. Sindhuja[2], J. Selvarani[1], R. Purvaja[1] and R. Ramesh[1]

The water quality problems of the Adyar River are mainly associated with outfalls from industries, commercial institutions, sewage treatment plants, pumping stations, sewers, storm water drains and slums. The present study is a new holistic approach to understand the various sources of pollution (point and non-point), in both the surface and the ground waters of the Adyar River. The river water and groundwater near the shore was found to be more polluted than the upper catchment, suggesting that the influence of the river water quality on the groundwater is much more in the coastal regions, due to the presence of shallow aquifer. The concentration of major ions and nutrients was found to be lower in the upper catchment. Chloride and Sodium were the dominant anion and cation respectively in the Adyar Estuary. Distinct spatial variability in nutrients especially N and P was apparent.

The H_2S concentration in the surface water ranged from 220 to 3018 mg l^{-1}. The dissolved O_2 was found to be maximum and H_2S concentration minimum near the coast indicating the existence of an inverse relationship.

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Abs. Nr. PO-122

Management of River Basin Fluxes – A Case study

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Today the Earth, with its diverse and abundant life forms, including over six billion humans, is facing a serious water crisis. The world population has increased by a factor of about three during the 20th century whereas water withdrawals have increased by a factor of about seven. It is estimated that currently one third of the world's population live in countries that experience medium to high water stress. This ratio is expected to grow to two thirds by 2025. It is estimated that more than 10% Indians lack access to protected drinking water and more than one third of Indian population do not get sufficient quantity of safe drinking water due to mismanagement of water resources.

All the signs suggest that it is getting worse and will continue to do so, unless corrective action is taken. Therefore, management of land and water resources has emerged as a vital issue in promoting bio-diversity and ecological security programmes. The basic message of ecological security is not of containing development to save ecology but of managing ecology to promote development. What is good for development is equally good for ecology. Developmentalists point out that development not only provides for all-round expansion of the economy but also builds capacity for improving the quality of ecology. Therefore, the basic issue is that the wheel of development must move on but it should advance within the supportive capacity of the ecosystem. Any desired development should have the ingredients of efficiency, equity and democracy. When this is done, the people tend to take eco-friendly decisions. The validity of the above idea is tested through a case study on Palar River basin. Management of Palar river basin against water pollution requires effective monitoring and implementation of protective measures not only for the management of water care but also for land care as well.

Thus, the paper attempts to analyze the grave problems posed by tannery effluents and outlines the remedial measures for effective management of river basin management to achieve sustainable development and livelihood security.

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Abs. Nr. PO-138

Groundwater Hydrochemical Processes in a Part of Lower Palar Basin, Tamil Nadu, India

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Groundwater samples were collected from an intensively irrigated region for a period of three months from the villages around vallipuram, Kancheepuram district, Tamil Nadu. The EC and pH values are measured in the field itself and the samples were analyzed for major cations such as Ca, Mg, Na, K and Major anions such as Cl, HCO_3, CO_3, SO_4. Concentrations of these cations and anions in the groundwater vary spatially and temporally. Abundance of these ions are in the following order: Ca>Na>Mg>K=HCO_3>Cl>CO_3>SO_4. Result of the chemical analysis was used to bring out the chemical processes such as dissolution precipitation, ion exchange and rock water interaction responsible for chemistry of groundwater. Ca-HCO_3 and Ca-Cl-HCO_3 are the dominant hydrogeochemical facies of the groundwater in the study area. Rock water interaction is the responsible for groundwater chemical composition. Interpretation of hydrochemical data suggests that calcium carbonate dissolution; ion exchange processes, silicate weathering and mixing of aerosols are responsible for the groundwater chemistry of the study area.

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