WATER IN MINING

Chaturvedi, A. C.

ABSTRACT : The run off data for several parts of our watershed in the mining areas has estimated computerisation of automatic stream gages. It has found that flood peaks were considerably reduced by the reduction of the contributing drainage areas while the low flow was increased from 15 to 50 percent. The river basin management has vast scope with use of modern innovations for detailed investigations with remote sensind and satellite based systems for watershed management. The importance and utility of collection and utilisation of vast amount of hydrogeological and pumping data is brought out in the computer oriented study of these problems.

RESUME : On a estimé, par computation, à partir des enregistrements automatiques de jaugeage, les ruissellements de nos bassins versants dans des zones minières. On a trouvé que les maxima des crues diminuent sensiblement, par réduction des surfaces versantes de drainage, tandis que les débits de base augmentent de 15 à 50 %. La gestion du bassin hydrographique a un large champ d'action, avec les apports des satellites et des télédétections. On met en évidence l'importance et l'utilité de la collecte et de l'emploi de la grande quantité de données hydrogéologiques et de sondage, par le traitement en ordinateur de ces problèmes.

RESUMEN : Se han estimado, por computación a partir de los registros automáticos de aforo, las escorrentías superficiales de nuestras cuencas vertientes, en áreas mineras. Se ha encontrado que los máximos de las crecidas disminuyen sensiblemente, por reducción de las superficies vertientes de drenaje, mientras que los caudales de base se incrementan entre el 15 y el 50 %. La gestión de la cuenca hidrográfica tiene un ámplio campo de acción, con las aportaciones de los satélites y sensores remotos. Se pone de manifiesto, la importancia y utilidad de la recolección y empleo de la gran cantidad de datos hidrogeológicos y de bombeo, mediante el tratamiento en ordenador de estos problemas.

Secretary, State Irrigation Commission, Canal Colony, Lucknow, India.

INTRODUCTION

Mining prospecting has a four fold increase in the National Fifth Five Year Plan of India and surface water hydrology has a significant role in this development. In the Eastern coal-field areas of the states of West Bengal, Bihar and Assam along with the Western coal field areas of Maharastra, Madhya Pradesh and Rajasthan, extensive measurements were undertaken of the seepage flow in these mines. Automatic stream gaging was undertaken and the data computerised to afford valuable results on the surface water contribution to excavation and underground works. Mathematical models were simulated to afford studies on drainage in the basins. Strip mining is found to have increased the flooding in mountain areas. Reclaimed and unreclaimed mines have been found to produce acid water containing heavy metals, sulphates and iron. Radio-active elements are found to have been produced in many of our coal mines. The productivity of the strip mined land is found to have been reduced. Application of methematical models to drainage irrigation is discussed. The positioning of mine in the western regions of our vast country which offers vast scope for exploitation of new and valuable minerals is detailed with special emphasis on rehabilitation potential. (CHATURVEDI 76)

Study of groundwater drawdown and recovery are important in the surface mining of coal in Jharia area. The effect of surface mining on two watersheds in the Eastern and Western belt of India is reviewed. The measurements indicated loss in water resources of the region to be greater in the Bihar state than in the state of Maharastra where new studies are to be forged ahead in the coming years. The criteria for selection of mine site is laid down detailing the importance of rehabilitation potential.

SHAPE OF CATCHMENT AREAS

The catchment or drainage area from which water is collected in the Indian rivers varies widely from river to river. The catchment of the cauvery river is 87000 sq.km. The water from the catchment flows into the main river through a number of tributaries and subsidiary streams. The patterns of the tributary system depend on the physical characteristics of the area, nature of rocks and their erodibility. The shape of the catchment influences the run off pattern of the river. (CHATURVEDI 77).

The western ghats watershed is located in Southern India. The peninsular rivers fall into two categories namely the coastal and the inland rivers. The coastal rivers are comparatively small streams. While 600 of such rivers drain into the sea near the West Coast, they are of a great importance. Although only 3% of the areal extent of the basins of India is drained by these rivers, as much as 14% of the country's water resources are contained in them. The Narmada and Tapi, between flanking mountain ranges have narrow elongated catchments. Near the valley the till is covered by rolling sandy hills of wind blown deposits bottom lands consist of unconsolidated fluvial sands and gravels or silts and clays. These deposits are overlain in places by recent silty loam alluvium.

There were 20 stream flow gages in this watershed. Five gages were installed in 1940 and the remaining 15 during 1950-70. The effects of strip mining on hydrology of Periyar river were determined from analysis of stream flow records for sub basins having different exposures to strip mining. Variations in flow characteristics were related to areas stripped in the sub-basin after accounting for differences which might be attributed to other causes.(CHATURVEDI 77).

The annual run off and seasonal distribution are given in Table 1 and 2 below:

Table 1. Area drained by the rivers and their average annual run off.

Sl. No.	Name of the river	Drainage Area Sq/km.	Area within Kerala Sq/km.	Average Annual Run off.(TMC/M.Cum.
1.	Periyar	5200	1996	428/12120
2.	Bharatpurha	3800	1492	221.5/6270
3.	Chabiyar(Beypore)	2400	940	160.5/4540
		1950	753	
4.	Paruba	1950	753	
		1540	600	222.8/6310
		1500	548	145.0/4110
5.	Kalibari(East flowing)	1710	456	76.0/2150
6.	Kallada	1140	456	93.7/2650
7.	Muvattupurha	1100	430	92.3/2610
8.	Meenachil			76.0/2150
9.	Acherkoil			77.3/2190
10.	Kadalundi	1000	391	75.9/2150

Table 2. Seasonal Distribution of the yield of Principal rivers.

Sl. No.	Name of the river	Percentage Yield June-Sept.	Oct.-Dec.	Jan.-May	Year for which average has been worked out.
1.	Periyar	77.5	18.5	4.0	1969
2.	Bharatpurha	72.0	26.0	2.0	1968
3.	Chabiyar (Baypore)	81.5	7.0	11.5	1970
4.	Pamba	74.5	24.5	1.0	1967
5.	Kabbaru	22.5	77.5	-	1966
6.	Kallada	51.5	44.0	4.5	1968
7.	Muvathupurha	68.0	27.0	5.0	1962
8.	Meerachil	72.0	26.0	2.0	1960
9.	Achenkoil	59.1	39.7	1.2	1967
10.	Kadalundi	62.0	36.0	2.0	1964
11.	Chalakudy	79.0	19.0	2.0	1970

Periyar gage and Bharatpurha record flows were from large contributive areas with varied run off conditions. These records are representative of the effects of strip mining as well as structural changes which have taken place in these water sheds. (CHATURVEDI 77).

ANALYSIS OF STREAMFLOW DATA

Records for the gaging stations formed the principal basis for comparisons to determine the effects of strip mining. The two sub basins are similar to size and most physiographic features and rainfall was found to be uniform over the water shed. The average monthly and annual discharges data for the coincident period for the six gages in the watershed indicates significant difference in annual unit discharge from some of the sub-basins. The Periyar sub-basin and the Bharatpurha sub basins show average annual unit discharge 15% greater and 15% less than the third river. Average annual discharges for the other stations show minor differences. The differences in the average monthly run off is greatest in the driest months. For the sub-basins affected by the strip mining, higher unit discharges are obtained during the low flow periods. Graphs of rainfall discharges and evapotranspirations for 10 days spell have been drawn and the resulting changes in the water storages for 10 days and for the cumulative periods were also plotted to demarcate water surplus and water deficit periods The study has revealed that sufficient change in water storage is available for consumptive use during the lean period. (CHATURVEDI 77).

These differences in the temporal distribution of flow are attributed to storage resulting from mining operations. Water is impounded in many small ponds and in the void area in the cast spoil. Much of the water is released over long periods as ground flow. Use of differential analysers, analogue and digital computors was traced for model studies. Ground water movement in different acquifers of varying geological strata called for use of isotopes and computors. The study of statistical dependencies and common mode failure provided interesting analysis. All these water resources problems were solved with availability series and parallel structures composed by repairable, unrepairable, and tested series. These studies were purposely designed to help us combat the absolescent malady offered a wide range of practical creative indepth learning the problem solving programme. The most probable effect of mining on water quality would be to reduce ground water discharge to Periyar Creek. Reduced discharge would provide less fresh waterto the lower reaches of the creek to dilute the saline water that is discharged to the surface water system in the North Central part of the basin. Based on current estimates the concentration of dissolved solids would be less than 5000 ml. per litre. Performance of the reservoir system design was evaluated by using historical stream flow data sequence with the implied assumption that performance under the past hydrologic input was the time indicator of the future performance. To design the system under the hydrological uncertainly therefore it was preferred to generate a number of synthetic streamflow sequênce that were statistically indistinguishable from the historical sequence and use them in computor simulation of system design. The conjunctive use of the synthetic data and simulation hastened the decision process by providing a more thorough evaluation of the alternative designs.

The deficit index used herein was tantamount to a linear time invariant loss function in which water deficit were penalised proportionately, with a little modification in the computor programme, it became possible to use more complicated functions capable of measuring non linear and corelated economic losses. The suitable model for flow synthesis was first searched. For simulation of reservoir operations, it was considered necessary to use atleast 10 day period as the minimum time unit. Accordingly to use model for generation of 10 day period flow sequence was evolved or selected. From the detailed analysis of the data, Fierings multiseasonal model was adopted. Flow duration curves were plotted for unit mean daily discharges for each of the stream flow records. These show creeks having lesser flow at lower exceedence levels than does Bharatpurha creek. The

Periyar creek having larger flows at greater exceedence level (higher sustained flows). This was also attributable to the effects of storage in the watersheds which retard flood flows and increased dry season base flows by realeasing water from the storage when streams were effluent.

To efficiently allocate water to meet developing energy resources and energy conversion facilities required giving attention to the interlocking energy and water resource system. The water needs of the system already constituted the major demand for water in the state of Kerala. The optimisation model was used as an example of a preliminary screenining model to examine trends and trade offs associated with selected planning alternatives. An important characteristics of these optimisation models was that they could be used to select alternative development patterns from among the almost infinite number of solutions . Any one mathematical model however took into account only a few aspects of major policy questions and was used in conjunction with other quantitative and qualitative analysis procedures within the planning activity.(CHATURVEDI 77).

Hydrographs exhibited both time and space changes resulting from the strip mining. Drastic changes in both stream chemistry and sediment load usually occurred downstream of the mined area thereby causing a significant alteration of the stream biota. Not all effects were negative in several observations increased ground and surface water storage resulted. The water availability in the Kerala State is the criterion that had to be considered first in any development supported for controlled by water. Because of the critical water balance in the future decades, the rules for water allocation and the constraints for water use were clearly defined at each stage of the plan. Preliminary values of future storage required under a 75% significant level were as given in table 3.

Table 3. Storage Requirements.

Decades	Years	Required storage (Cum./Sec.)
1	1970-79	50
2	1980-90	60
3	1991-2000	70
4	2001-2010	85
5	2010-2020	105
6	2021-2030	140

The hydraulic structures required to ensure this storage represented one of the main economic inputs of the whole plan. Finally the loss of water availability due to non predicted pollution was not considered nevertheless if the appropriate pollution controls were not established from the begining, then the balance was subject to change. The equilibrium between the annual total surplus and the total annual deficit was obtained, when the requirement function intercepted the long term mean of the water availabilities and this point gave the total duration of the plan under the hypothesis of self sufficiency. The assumption of annual balance was a restricted one. (CHATURVEDI 77).

MATHEMATICAL MODELS

Development and construction of systems for control of drainage basin waters for useful purposes is very essential in our state of Uttar Pradesh. The use of these analytical techniques required a close relationship with the data analysis activities. A mathematical model often aids in the determination of the amount, location and type of the data to be collected. But thinking in terms of the rivers model which very significantly from one to the other, collection of the real data is necessary These data help to shape the model and through verification analysis, indicate the appropriateness of the model. After verification some basis exists for making projections, on the effect of control procedures. The Jharia water shed is a system where the input is also the amount of the rainfall falling on the drainage area which transformed the input rainfall to an output namely runoff. In our dynamic model, the forcing function was time variable. Spatial gradients existed in the system. The fundamental idea in the deterministic relationship was to write a mass balance equation for the elemental volume which gave an account of all the materials entering and leaving the basin. Mathematically the system remained linear under the first order assumption which was useful as superposition was applied. For higher grder urn-linear type reactions simultaneous type of reaction simulative analysis became necessary.((CHATURVEDI 77).

Simulation models were effectively used for the determination of flow conditions in acquifers in the case of recharge for supply of ground water. Some important differences were found in the study of the model. Flood frequency curves of unit discharges above selected bases, partial duration series were plotted for Chebiyar, Bharatpurha, indicating widely diverse flood peak producing conditions. The resulting analytical expression was :

$Y = 34.2046\ e.^{0268}$ where Y represented the water demand in cubic metres/sec. and X was the time variable in years with X=1 for 1974. The annual water availability was considered as a normal variable with mean X= 701.10 cubic metres/sec. 1

and substandard derivation S= 132.06 cubic metres/sec. For interpretation purposes the time period from the begining of the plan was divided into decades, the first one starting in 1950.

The probability distribution of the dry and wet years respectively was plotted for different stages of the rivers. The probabilities of dry and wet years for different decades were worked.out. The probability of having a drought or wet period of two years duration at the beginning of the 6th decade was 0.7 x 10 and 1.26x10 respectively, lag times from the centroid of rainfalls to peak discharges were determined for the three creeks for recorded coincident floods. Expected time lags were calculated using the lag time in hour values for the non mined east drainage areas, the coefficient was calculated to be 2.15. Disregarding the effects of strip mining, the Pamba and the Minachil creek drainage areas were hydrologically similar to the Chabiyar creek area. That is characteristics such as soil type, vegetal cover, geographical area and climatic exposures were the same. The variable factors such as sub-basin shape and drainage areas were accounted for. (CHATURVEDI 77).

The system stimulated by the model (38864 sq/kms.) was divided into 3440 model areas. Two dimensional non steady flow in non homogenous isotropic acquifer was simulated. The model was calibrated by comparing computor output heads in nodes with known water level elevations in 48 observations points. No attempt was made to achieve an absolute correspondence between the model and nature. A total of 60 separate computor runs of the model were made, reducing the average error from 5.7 to 3.8 m. The small number of calibration runs in this model was commensurate with the quality and quantity of the control points. Input parameters to the model were: infiltration rate, transmissivity and storage coefficient of the acquifer fixed surface water levels and selected nodes.

The computor yielded preliminary water balance steady state water level map, corrected transmissivity distribution modified recharge, infiltration to the acquifer. Twelve exploitation schemes were tested. Testing time was from 5 to 20 years with a cycling pumping pattern 6 months of pumping followed by 6 months of pumping followed by 6 months of idling. The amount of withdrawal was 17 to 30 cum. /sec. Several initial schemes were tested on a 40x26 array of model points and the last six on a 40x30 array. The model grid was plotted on the horizontal coordinate directions. The nodes were numbered from 1=1 to 1=401 and from J=1 to J=3.

The inclusion of the simulation by the model phase between the two actual investigation phases was of special importance. There were manifold benefits: confirmation of the conclusion of the previous investigations in a regional sense, provision of guidelines for future data selection and preliminary location of well fields in an optimal manner for future operating conditions.

Acquifers were operated with increasing frequency in recent years as a sole source of large amounts of water in a conjunctive manner with surface water system. It has been more fully realised during the last decade that refined quantitative answers were need concerning available basin resources. Proper planning and management of basin water resources required the testing of all possible schemes and appraising of the merit of various alternatives. The fast speed hardware provided the basin hydrology and the resource engineers with an efficient too for evaluation of surface water resources and the consequences of the utilisation of the acquifers. The sequence of investigation followed in these models was adopted in other basins of the various states of the Indian Republic for evaluation and valuation of surface water potentialities in similar areas of hydrological structures size and economic status. The water balances, calculated by the computor at the end of every section in every tested scheme was plotted and gave the resultsfor the entire system in the exploitable conditions. (CHATURVEDI 77).

REHABILITATION

Surface rivers have led to environmental economic and social degradation of most of these locations. Land development programme have been developed and implemented in Kerala with extensive,coordinated successful effort in freezing injection and cementing. It is quite likely therefore that some perhaps, most future surfaces mines will affect surrounding areas in a similar manner. The conditions of the site at the time of disturbance were restored afterwards. The site was habitable to organisms either originally present or similar to the original inhabitants. After rehabilitation the land was returned to a farm and productivity that conformed with a prior land use which accounted for establishing a stable, environmentally acceptable ecological state. Surface mines in the water abundant (typical mean annual precipitation of 88 cm.) western Kerala affected with water quality and quantity within the stream channel. In using the water allocation model, the change on the limits of the total. Withdrawals from the given river was shown and the different model solutions offerred the impact on the water allocation pattern of the regièn. The different solutions specified different locations on the water facilities. The model dealt with the water source points which included the major river reaches groundwater acquifers and potential reservoir sites,municipal, and non power industrial water demand points and load centres for electric-power demands.

The linear programming model minimised the sum of the transportation cost of all of the commodities and the site dependent costs of supplying water. These costs depended on the flow paths selected by the model for the four commodities and these flow paths depended in part on the locations selected for the energy facilities. The site dependent cost for energy facilities were readily incorporated into the cost coefficients of the model. (CHATURVEDI 76).

CONCLUSION

The control of ground water pressure, is an important component activity for mining in South India. Since the commencement of mining operations a lot of hydrological and pumping data has been collected since 1940. With the availability of the data and the likelihood of more severe hydrological conditions being encountered in mining in the coming decade, a computor oriented study of the problem of mine water control was initiated.

Reservoir systems are to be designed in the face of hydrologic uncertainty. An investigation into the effect of this uncertainty on the performance of a system design is the basic objective. Synthetic streamflow data were generated by evolving a flow model and alternate sequences were used in simulation of reservoir operations. The performance of the design was measured by the deficit index. Variat on in the deficit index when alternate synthetic data sequences were used reflected the hydrologic uncertainty involved. An objective approach to the determination of the adequacy of synthetic data sequences was worked in terms of the desired accuracy of the estimate of deficit index. The extreme low flow volume for Bharatpurha creek were 5 to 15 times greater than the corrèsponding values on the Chabiyar creek. In each case the comparison of the least square feet time and the equal yield line shows for the sub basins affected by strip mining, higher unit discharge during low flow periods.

REFERENCES

CHATURVEDI A.C. 1976. System Science in Water Management- Proceedings of International Symposium, Technical University, Wroclaw, Poland. P.40.

CHATURVEDI A.C. 1977. Information Control in Manufacture. Rapers of HAC Symposium on Information Control Problem in Manufacturing Technology- The Society of Instrument and Control Engineers, Minato Ku, Tokyo. P.48.

CHATURVEDI A.C. 1977. Designs for Low Ground Water Structures, National Symposium of Indian Association of Geohydrologists. P.30.

CHATURVEDI A.C. 1977. Water Quality and Availability in U.P.-India. Papers of Third International Hydrology

Symposium , Fort Collins, State University, Colorado. P.100.

CHATURVEDI A.C. 1977.Water resources Information- Papers of Third International Seminar on Water Resources Information, State University, Fort Collins, Colorado.P.120.

CHATURVEDI A.C.1977. Optimisation in Irrigation- Papers of All India Seminar on Automatic Control, Institution of Engineers, Calcutta. P.49.

CHATURVEDI A.C. 1977. Irrigation Modelling in India. Proceedings of International Conference on System Science IV, Technical University, Wroclaw.Poland.P.140.

CHATURVEDI A.C. 1977. Urban, Regional and National Planning in India. Papers of IFAC Workshop on UNRENAP Organising Committee. Tokyo. P. 26.

CHATURVEDI A.C. 1977. Data Processing Optimisation. Papers of Fourth International Seminar. Bulgarian Academy of Sciences. Verna. Sofia. P. 72.

CHATURVEDI A.C. 1977. Planning for Ground Resources. Papers of Environmental Division Meeting Institution of Engineers. P.44.

CHATURVEDI A.C. 1976. Space Electronics in 2000 AD. Papers of All India Seminar, Jadavpur University, P.82.