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Land Allocation Strategies Through Genetic Algorithm Approach–A Case Study

Gopi.Annepu[α], K.Venkata Subbaiah[Ω], N.R.Kandukuri[β]

Abstract - Development of agriculture depends on optimal land allocation. The development towards optimal utilization of land under cultivation and thereby increasing the production of crops and profit with less fertilizer consumption have to be taken into consideration in agriculture planning. In this paper different agriculture strategies are developed and accordingly, single objective optimization models are formulated with net profit, production of crops and fertilizer consumption as objectives and availability of cultivable land, agriculture labor, agriculture machinery and water as constraints. To illustrate the models a case study of Visakhapatnam district, Andhra Pradesh, India is presented and are solved through GA.

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I. Introduction

In developing countries, the agricultural sector's performance determines overall economic growth, trade expansion, and increased income-earning opportunities. Implementing policies that encourage greater agricultural productivity, Profitability and sound environmental management is very much needed. In today's globalized world every sector of the economy needs to reorient itself to meet the changing demand. This is very much required as the need patterns of the individuals are getting transformed by the intensity of the local and global forces. The rural sectors of the developing countries are not exceptions in this regard. The sudden boom in food retail sectors has also changed the orientation and status of farming from purely individualistic to group oriented activities in India. At this instance it is inevitable for a country like India to improve its agriculture production not only to meet the demand of food grains for the growing population but also to improve the economic conditions of the majority population who live in rural areas. As a result of losing land due to growing population and industrialization, the production of crop per unit area must be increased by proper utilization of resources. One way of increasing production of crops is by increasing the area under cultivation. Planning of crops is the most crucial factor of Agriculture Planning which depends on several resources like availability of land, water, labour, machinery and capital.

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Ahmad et al. (1990) used LP model for developing optimal farm plans for small farmers in Leiah Tehsil and Faisalabad. Srinivasa Raju and Nagesh Kumar (2000) developed a LP irrigation planning model for the evaluation of irrigation development strategy and applied to a case study of Sri Rama Sagar project, Andhra Pradesh, India with the objective of maximization of net benefits. Singh et al. (2001) used a LP model to reach optimized crop pattern at various available water levels. Ishtiaq Hassan et al. (2005) presented a model to determine the optimum cropping pattern of Punjab in Pakistan. Mohmoud et al. (2009) adopted a LP model to find the optimal cropping pattern, in Taybad of Khorasn Razavi state in Iran. Felix and Judith (2010) developed an LP planning model for a Farm Resource Allocation Problem and applied to a Case Study of small scale commercial farmers in Zimbabwe.

Haouari and Azaiez (2001) presented a mathematical programming for determining crop pattern in dry lands under scarce of water resources. Willem et al. (2006) applied a genetic algorithm to minimize agricultural nitrogen deposition in nature reserves.

As evolutionary algorithms offer relatively more flexible way to analyze and solve realistic engineering problems is increased. The best known algorithms in this class are Genetic Algorithms (GAs).The Genetic Algorithm (GA) imitates the natural Darwinian evolution process, was originally conceived by John Holland (1975) of the University of Michigan, Ann Arbor.

Two important flavors of GA are Binary GA and Real parameter GA. The binary GA is not suitable to achieve any arbitrary precision in the solution. The more the required precision, then the larger is the string length. If the string length is large, the population size is large (Goldberg et al., 1992), thereby increasing the computational complexity of the algorithm. To overcome this difficulty and to increase the precision it is more logical to represent the variables which are continuous by real parameter values (floating point numbers). Real coded or floating point representation has a very good usage because of the empirical findings that real codlings have worked well in a number of practical applications. The real parameter GA has also the advantage of less required storage space than the binary GA because a single real parameter value represents the variable instead of m (bits) integers. Also

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real parameter GAs deal with real parameter values and bring the GA technique a step closer to the classical optimization algorithms (Deb, 2001).

In this paper, single objective optimization models are developed by considering the strategy of the decision maker/ policy makers. Further the models are solved through real parameter Genetic Algorithm approach.

II. Model Formulation

Enhancing productivity growth in a sustainable way that makes economic, social and environmental sense and delivers food security is key issue in determining the strategies for growth in agriculture sector. The highest leverage point could be a shift from individual crop-focused research to an eco-region specific strategy. Agricultural research and development strategies must take into account natural resource endowments and also the prevailing socio-economic conditions (as reflected in current crop patterns, yields, market access and so on) under which farmers work.

In this context, three objectives namely, maximization of production, maximization of profit and minimization of fertilizer consumption are modeled by considering the strategies with social, economic and environmental sense for optimal land allocation. The following steps explain the formulation and complete solution procedure for optimal allocation of land for major crops under three strategies.

a) *Notations*

L = Total area of land (hectares) available under cultivation

EMD = Estimated number of man days (days) available throughout the year.

EMH = Estimated number of machine hours (hrs.) available throughout the year.

$[WA]_s$ = Total amount of water (cm) available during the seasons s.

$[PR]_{cvs}$ = Production (quintal) per unit area of land cultivated for the variety v of crop c during the seasons s.

$[Md]_{cvs}$ = Man days (days) required per unit area of land cultivated for the crop c, variety v during the season s.

$[mh]_{cvs}$ = Machine hours (hrs.) required for tillage per unit area of land cultivated for the variety v of crop c during the season s.

$[WC]_{cvs}$ = Amount of water consumed (cm) per hectare of land cultivated during a season s for the crop c of variety v.

$[HP]_{cvs}$ = Harvest price (Rs. /quintal) of the variety of v of crop c cultivated during the season s.

$[MSP]_{cvs}$ = Minimum support price (Rs.) declared by the government for the variety v of crop c during the season s.

$[N+P+K]_{cvs}$ = Nitrogen, Phosperous and Potassium (kg/hectare) required for the variety v of crop c during the season s.

$[H]_{cvs}$ = The area of land required for cultivating the crop c, variety v, during the season s in hectares.

b) *Strategies*

Three strategies namely, societal, economic and environmental are considered in this study.

Societal Strategy: Increase in agricultural productivity must be accelerated to bring down current levels of food insecurity and meet the food and income needs of new populations. Hence, due consideration shall be given for Maximization of production. To meet the demand of food-stuff the annual production of all the major crops must be maximized. The mathematical formulation of the objective is shown below.

$$\text{Maximize Production}(Z_1)=\sum_{c=1}^{C}\sum_{v=1}^{V}\sum_{s=1}^{S}[H]_{cvs}*[PR]_{cvs}$$

Subject to constraints given in section 2.3

Economical strategy: The agricultural sector's performance determines overall economic growth, trade expansion, and increased income-earning opportunities of farmers. Implementing policies that encourage, Profitability is very much needed. To increase the economical and social status of the farmers the net profit must be maximized. The mathematical formulation of the objective is shown below.

$$\text{Maximize Profit}(Z_2)=\sum_{c=1}^{C}\sum_{v=1}^{V}\sum_{s=1}^{S}[MSP]_{cvs}*[PR]_{cvs}*[H]_{cvs}-\sum_{c=1}^{C}\sum_{v=1}^{V}\sum_{s=1}^{S}[HP]_{cvs}*[PR]_{cvs}*[H]_{cvs}$$

Subject to constraints given in section 2.3

Environmental strategy: The challenge relating to this, land area is to maintain its fertility status and protect against degradation due to soil erosion, chemicalization, water logging and Stalinization and alike problems. Use of chemical fertilizer is held responsible for soil degradation and environmental pollution. The reason for adverse impact of chemical fertilizer is because of excessive, indiscriminate and non-judicious use. To reduce the environmental pollution and cost of fertilizer the fertilizer consumption must be minimized. The mathematical formulation of the objective is shown below.

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$$Minimize\ fertlizer\ consumption\,(Z_3) = \sum_{c=1}^{C} \sum_{v=1}^{V} \sum_{s=1}^{S} [H]_{cvs} * [N+P+K]_{cvs}$$

Subject to constraints given in section 2.3

c) Constraints

In agriculture planning, optimal land allocation depends on various constraints. The mathematical formulations of the constraints considered in this work are as follows.

Land (C_1) : It is necessary to utilize the land in all seasons because of its limited availability.

$$\sum_{c=1}^{C} \sum_{i=1}^{s} \sum_{V=1}^{S-i+1} [H]_{cvi} - \sum_{c=1}^{C} \sum_{i=1}^{s} \sum_{v=0}^{S-i} [H]_{cvi} \le L$$

$$where [H]_{coi} = 0\ for\ all\ c,\ i\ and\ s = 1,2...S;$$

After harvesting a crop in a season, the available land can be reutilized for cultivating the crops in the next season.

$$\sum_{c=1}^{C} \sum_{i=1}^{S-1} [H]_{c,s-i,i} - \sum_{c=1}^{C} \sum_{v=1}^{S-s+1} [H]_{c,v,s} = 0\ for\ s = 2,3,...S$$

Agriculture labour (C_2): It is necessary to utilize the agriculture labour in all seasons, because of the limited availability of laborers.

$$\sum_{c=1}^{C} \sum_{v=1}^{V} \sum_{s=1}^{S} [md]_{cvs} * [H]_{cvs} \le EMD$$

Agriculture machinery (C_3): It is necessary to utilize the agriculture machinery for tillage in all seasons, because of the limited availability of machinery.

$$\sum_{c=1}^{C} \sum_{v=1}^{V} \sum_{s=1}^{S} [mh]_{cvs} * [H]_{cvs} \le EMH$$

Water (C_4): To meet the production level of each crop, it is necessary to utilize available water in all seasons.

$$\sum_{c=1}^{C} \sum_{v=1}^{V} \sum_{s=1}^{S} [WC]_{cvs} * [H]_{cvs} \le [WA]_s\ for\ s = 1,2..S$$

d) Obtaining Solution through GA

Three single objective optimization models are developed under each strategy with respective objective functions Z_1, Z_2 and Z_3. The formulated models may be solved through various optimization techniques. In this study a real parameter GA approach is used to solve models

The mechanism of real parameter GA consists of the following components.

- Genetic representation for potential solutions to the problem
- An initial population of potential solutions
- Evolution function (fitness function) that plays the role of the environment, rating solutions in terms of their fitness
- Genetic operators that alter the composition of children (reproduction, crossover and mutation)
- Values for various parameters that the GA uses (population size, number of generations, probabilities of applying genetic operators)

III. CASE STUDY

The model formulated in the previous section is explained with a case study of Visakhapatnam district in Andhra Pradesh, India. According to the climatic conditions, two cropping seasons Kharif and Rabi are considered. The main crops cultivated during Kharif (June to September) and Rabi (October to February) seasons are Paddy, Black Gram, Green Gram, Ragi, Maize, Groundnut, Chillies, Sugarcane. Sugarcane is perennial crop and occupies the land in both the seasons. After harvesting the crops of short period in the Kharif season, the same land is utilized for cultivating late variety of Maize. Similarly in the Rabi season after harvesting the early variety of crops Black Gram and Green gram, the same land is utilized for cultivating late variety of same crops. In the model formulation, the crops are numbered as c = 1 for Paddy, c = 2 for Black ram, c = 3 for Green Gram, c = 4 for Ragi, c = 5 for Maize, c = 6 for Groundnut, c = 7 for Chillies and C = 8 for Sugar Cane, Seasons are denoted as S = 1 for Kharif and S = 2 for Rabi, Varieties are denoted as V = 1 for first variety or early variety and V = 2 for second variety or late variety. The data for the available resources, defined coefficients of objectives and constraints are presented in Table 1 and 2.

Table 1: Data of available resources

Land under cultivation in Kharif season (hectares)	L_1	230068
Land under cultivation in season (hectares)	L_2	38359
Man days(days)	EMD	58300000
Machine hours (hrs)	EMH	15292800
Water during Kharif season (cm)	$[WA]_1$	23656516
Water during Rabi season (cm)	$[WA]_2$	15265830

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Table 2: *Data for the co-efficients of objectives and constraints*

Coefficients	Season	Paddy	Black Gram	Green Gram	Ragi	Maize	Ground nut	Chilli	Sugarcane
Production (qtl/hect)	Kharif Rabi	16.83 19	4.2 6.7(6.5)	3.94 3.4(3.5)	5.95 15.5	14.26(13.5) 88.3	11.16 22.41	44.65 12.43	420
Market price (Rs/qtl)	Kharif Rabi	850 850	2520 2520(2520)	2520 2520(2520)	915 915	840 (840) 840	2100 2100	2200 2200	108
Harvest price (Rs/hect)	Kharif Rabi	8836 9975	6002 9574(9289)	5630 4859(5002)	2874 7487	7330(6939) 45386	16104 32338	63046 17552	35280
M/c hours (hrs/hect)	Kharif Rabi	4 6	0 0	0 0	4 4	(4) 4	6 6	4 4	8 8
Man days (days/hect)	Kharif Rabi	150 175	52 60 (58)	54 45 (48)	52 54	96 (92) 98	75 75	603 658	155
Fertilizer (kg/hect)	Kharif Rabi	135 135	100 100 (100)	100 100 (100)	100 100	180 (180) 180	110 110	160 160	200
Water (cm/hect)	Kharif Rabi	130 130	35 40 (40)	35 40 (40)	40 45	50 55	45 60	55 60	180

Note: The data shown in brackets corresponds to the late variety of crops.

a) Strategies

Societal Strategy

$$Maximize\ Production(Z_1) =$$

$$16.83*H_{111}+19*H_{112}+4.2*H_{211}+6.7*H_{212}+6.5*H_{222}+3.94*H_{311}+3.4*H_{312}+3.5*H_{322}+5.95*H_{411}+15.5*H_{412}+14.26*H_{511}+88.3*H_{512}+13.5*H_{521}+11.16*H_{611}+22.41*H_{612}+44.65*H_{711}+12.43*H_{712}+420*H_{811})$$

Subject to constraints given in section 3.2

Economical Strategy

$$Maximize\ Profit(Z_2) =$$

$$(14306*H_{111}+16150*H_{112}+10584*H_{211}+16884*H_{212}+16830*H_{222}+9929*_{H311}+8568*H_{312}+8820*H_{322}+5444*H_{411}+14183*H_{412}+11978*H_{511}+74172*H_{512}+11340*H_{521}+23436*H_{611}+47061*H_{612}+98230*H_{711}+27346*H_{712}+45360*H_{811})-$$

$$(8836*H_{111}+9975*H_{112}+6002*H_{211}+9574*H_{212}+9289*H_{222}+5630*H_{311}+4859*H_{312}+5002*H_{322}+2874*H_{411}+7487*H_{412}+7330*H_{511}+45386*H_{512}+6939*H_{521}+16104*H_{611}+32338*H_{612}+63046*H_{711}+17552*H_{712}+35280*H_{811})$$

Subject to constraints given in section 3.2

Environmental Strategy

Minimize Fertilizer Consumption (Z_3) =

$$H_{111}*(70+35+30)+H_{112}*(70+35+30)+H_{211}*(20+50+30)+H_{212}*(20+50+30)+H_{222}*(20+50+30)+H_{311}*(20+50+30)+H_{312}*(20+50+30)+H_{322}*(20+50+30)+H_{411}*(50+30+20)+H_{412}*(50+30+20)+H_{511}*(100+50+30)+H_{512}*(100+50+30)+H_{521}*(100+50+30)+H_{611}*(30+40+40)+H_{612}*(30+40+40)+H_{711}*(80+50+30)+H_{712}*(80+50+30)+H_{811}*(80+20+100);$$

Subject to constraints given in section 2.3.1 to 2.3.4.

b) Constraints

Land in Kharif season

$$H_{111}+H_{211}+H_{311}+H_{411}+H_{511}+H_{611}+H_{711}+H_{811}<=230068;$$

Land in Rabi season

$$H_{112}+H_{212}+H_{312}+H_{412}+H_{512}+H_{612}+H_{712}<=38359;$$

Reutilization of land in next season

$$H_{212}+H_{312}-H_{222}-H_{322}=0;$$

$$H_{211}+H_{311}-H_{521}=0;$$

Agriculture labor

$$150*H_{111}+175*H_{112}+52*H_{211}+60*H_{212}+58*H_{222}+54*H_{311}+45*H_{312}+48*H_{322}+52*H_{411}+54*H_{412}+96*H_{511}+98*H_{512}+92*H_{521}+75*H_{611}+75*H_{612}+609*H_{711}+658*H_{712}+155*H_{811}<=58300000;$$

Agriculture machine hours

$$4*H_{111}+6*H_{112}+4*H_{411}+4*H_{412}+4*H_{511}+5*H_{512}+4*H_{521}+6*H_{611}+6*H_{612}+4*H_{711}+4*H_{712}+8*H_{811}<=15292800;$$

Water in Kharif season

$$130*H_{111}+35*H_{211}+35*H_{311}+40*H_{411}+50*H_{511}+50*H_{521}+45*H_{611}+55*H_{711}+180*H_{811}<=23656516;$$

Water in Rabi season

$$130*H_{112}+40*H_{212}+40*H_{222}+40*H_{312}+40*H_{322}+45*H_{412}+55*H_{512}+60*H_{612}+60*H_{712}+180*H_{811}<=15265830;$$

c) Obtaining Solution through GA

The multi objective problem converted to a single objective problem and is solved through real parameter genetic algorithm. The real coded GA used to find the optimum solution implements a tournament selected scheme, where two solutions are compared and the best in terms of objective function value is selected. Crossing over is done by the simulated binary crossover SBX operator which works with two parent solutions and creates two offspring (Deb and Agarwal,

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1995). To create a mutated value, the polynomial mutation operator (Deb, 2001) is used. The exponents used for SBX and mutation are 2 and 100 respectively. Constraints are handled using Deb's parameter-less approach (Deb, 2000).

In most of the constrained optimization problems, the fitness function is obtained by adding a penalty proportional to the constraint violations to the objective function value. The constraint handling methods can be classified into five categories (Michalewicz et al. 2000). They are the methods based on preserving feasibility of solutions, penalty function, feasible over infeasible solutions, decoders and hybrid methods. Among these methods the method feasible over infeasible solutions is found to have more efficient and more robust than the penalty based methods (Deb, 2000). This method sometimes called as Deb's penalty parameter less approach and the same is used in the present work.

As GAs do not have a mathematical convergence, a parametric study is carried out by varying crossover probability (Pc), mutation probability (Pm), population size (Ps), and number of generations (Gn). By this study the best value of the each objective function was found with the best set of GA parameters obtained. The best GA parameters obtained are Pc=0.81, Pm=0.01, Ps=30,Gn=150.

IV. Results and Discussion

Table 3 shows the results obtained for optimal land allocation for Societal, Economical and Environmental strategies for eight major crops through GA by considering the best combination of GA parameters.

Table 3: *Optimal land allocation*

S1. No.	Crops	Decision variables	Societal Strategy	Economical Strategy	Environmental Strategy
1.	Paddy	H_{111} H_{112}	95717.061 3998.393	95591.791 3841.478	98782.757 3985.636
2.	Black Gram	H_{211} H_{212} H_{222}	3999.996 2999.86 2999.703	3993.851 2999.754 2999.993	3998.554 2999.131 2996.617
3.	Green Gram	H_{311} H_{312} H_{322}	1999.993 3998.561 3997.853	1993.141 3999.956 3986.554	1986.469 3998.911 3995.135
4.	Ragi	H_{411} H_{412}	29999.835 997.784	29999.236 998.401	26368.929 739.977
5.	Maize	H_{511} H_{512} H_{521}	6976.733 1986.27 6999.987	6999.994 1999.998 6999.993	6996.454 1824.971 6997.61
6.	Ground nut	H_{611} H_{612}	5674.112 1999.968	5999.481 1999.829	5992.744 1882.969
7.	Chillies	H_{711} H_{712}	997.949 2999.983	999.979 2999.888	730.743 2999.919
8.	Sugarcane	H_{811}	49999.973	49999.967	48700.802
Total land allocated in			228344.014	228403.284	225978.328

The results exhibits that the total land utilization for eight major crops in kharif season with societal, economical and environmental strategies are 87.96%, 88.05 and 87.17% respectively. Similarly, land utilization in rabi season are 67.72%, 67.32% and 66.28%. It also shows that there is a maximum land allocation (228403.284 hectares) by economical strategy as compared with other strategies. Comparison of land allocation for eight major crops among three strategies is shown in the figure 1.

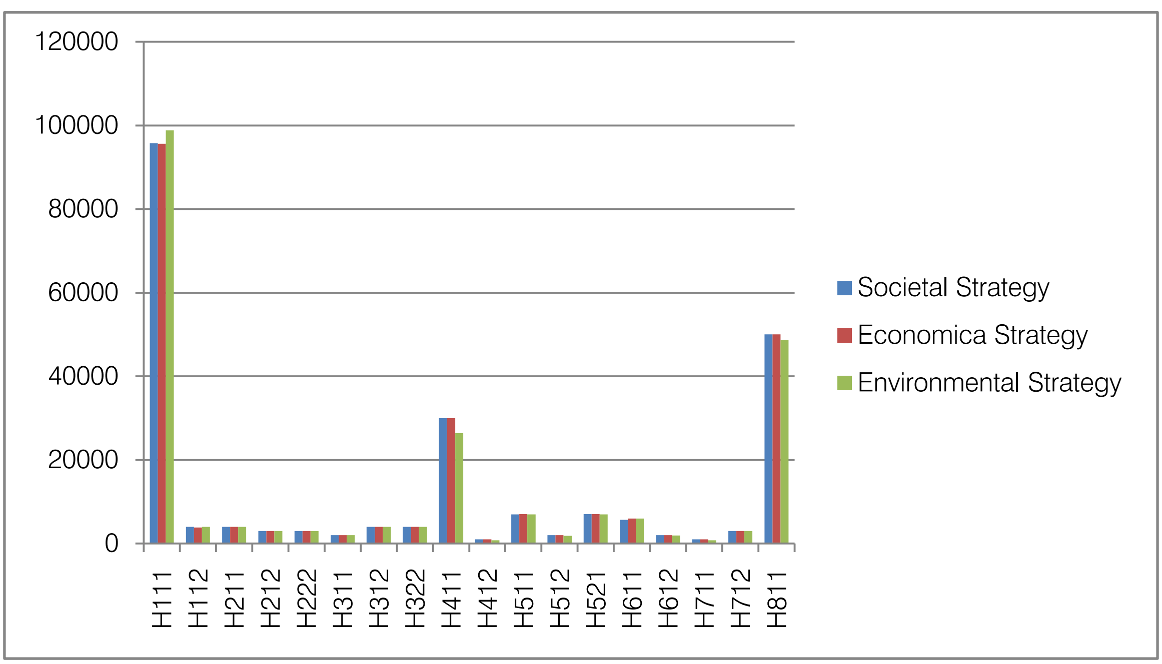

Figure 1: *Land allocation for eight major crops*

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From the figure 1 it is observed that there is marked difference in land allocation in environmental strategy for the crops - paddy (H111), Maize (H111) and sugarcane (H811) when compared with the other strategies.

Table 4: Level of achievement of Objectives under different strategies

S.no	Objectives	Societal Strategy	Economical Strategy	Environmental Strategy
1	Production	23532072 (99.99%)	23532161 (100%)	22987090 (97.68%)
2	Profit	1492216509 (99.91%)	1493427936 (100%)	1471302386 (98.52%)
3	Fertilizer consumption	32918096 (99.13%)	32920473 (99.13%)	32632926 (100%)

Note: Figures within the parenthesis indicate the Percentage of attainment to its maximum or minimum value as of the case of the objective

The attainment levels of various objectives in percentage are given in table 4. From the results it is observed that production and profit objectives are maximum with economical strategy. With environmental strategy, fertilizer consumption is minimum. Further, one can observe that the societal strategy is also competing with other two strategies. Level of achievement of Objectives under different strategies is shown in figure 2.

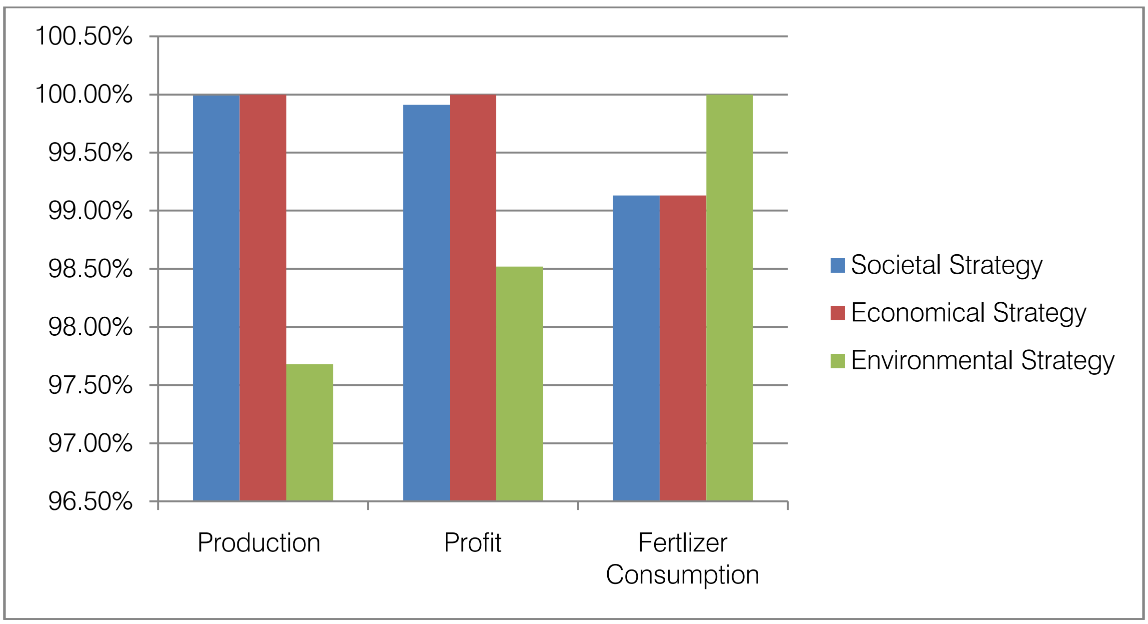

Fig 2: Level of achievement of Objectives

From figure 2, it is observed that there is variation in level of achievement of the objectives with environmental strategy when compared to the other strategies.

V. Conclusion

This paper presents three strategies for optimal allocation of land for eight major crops in two seasons and for two crop varieties of Visakhapatnam district in Andhra Pradesh, India. The models proposed in this paper are solved through real parameter GA for optimal solution by parametric study.

The land planning based on the results achieved with the help of genetic algorithm will lead towards a development strategy in the rural sector through agriculture. In a country like India whose rural economy is mostly agriculture based, a sustainable development in the context of globalization is only possible by way of improved land, societal, economical and environmental strategies by reorganizing land allocation system for various agricultural activities keeping in view of the local and market requirements. This model is based on single objective optimization depending on the strategy of the agriculture planners subject to the resource and conditional constraints. By using this model the cultivated land can be reorganized to get maximum satisfaction of the stakeholders of the rural area and hence lead to sustainable development in agriculture. The model developed does not taken care of uncertainty in the objectives and constraints. Future researchers may also include vagueness and stochastic uncertainty in decision variables, coefficients, objectives and constraints.

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Exploratory Survey of Geochemical Aspects of Underground Water in Ehime Mbano Area Se Nigeria

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Abstract- The exploratory survey of geochemical aspects of underground water resource in Ehime Mbano area of Imo State South-eastern Nigeria has been carried out. Since the creation of Ehime Mbano Local government area in 2001, there is the need for sub surface water quality assessment since the surface water has been polluted due to population explosion. The study was carried out by acquiring geologic and topographic maps of the area for easy identification of sample population areas, and to identify geological boundaries. Spring outcrops, landuse elements, especially waste dump sites and agricultural projects were visited and examined.

A total of 6 water samples, 2 from springs and 4 from boreholes were collected randomly and analysed. Analysis was carried out using atomic absorption spectroscopy for major cations. Heavy metal analysis was undertaken using spectrophotometer, potassium was determined using flame photometer method, concentration of total iron (Fe2+) was determined calorimetrically using spekker absorption meter, while total dissolved solids (TDS) was determined using glass fiber filter. Turbimetric method was used to assess turbidity. Physical parameters like ph and dissolved oxygen were measured insitu in the field with appropriate standard meters.

The result of geochemical survey shows that the water has high turbidity, high iron, slightly acidic, soft , portable and suitable for domestic, industrial and irrigation purposes. Above all the water has no bacteria presence, no heavy metals also no laxative effect. The average pollutional index of 2.50 indicates a slight pollution though Ezeoke Nsu area (NE) is highly polluted.

Remediation to the problems of slight water pollution is proposed.

Keywords: *Exploratory Survey, ground water, quality, population, contamination, subsurface.*

Classification: *GJRE-J Classification: FOR Code: 090906*

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Onunkwo – A[α], Uzoije A.P[Ω]

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I. Introduction

The political creation of local government in Nigeria caused a new population explosion in villages which were raised to urban status. Ehime Mbano area of Imo State, Nigeria witnessed an upsurge of population explosion since the creation of Ehime Mbano Local Government. This new trend calls for exploratory survey of the nature, usability and quality of the sub surface water resource, since the new trend of urbanization calls for industrial establishments and portable water.

Rock types, their weathered products and precipitation from rainfall contribute greatly to the chemistry and pollutional trend of surface and ground water (Wilson, 1981). Man's activities such as dumping of refuse, agricultural practices and animal dung also determine the pollution of surface and ground water (Horton, 1995). Groundwater pollution may also be caused by the disposal of solid or liquid wastes in pits, abandoned boreholes or even stream channels and landfills. Others are poorly constructed or designed septic tanks, sewage disposal systems (Ellis, 1988). Chemicals such as lead, arsenic and radioactive minerals derived from chemical waste disposal sites of factories and mining industries also contribute possible pollutants. The introduction of contaminant or pollutant into an aquifer system starts with the infiltration of the pollutant through a water medium induced by precipitation. Ground water pollution may be a point or diffuse source (Todd, 1959). Point source of groundwater pollution may result from the location of a disposal pits, ponds or lagoons, mines or industrial wastes, disposal points, direct into an unconfined aquifer system. Diffused groundwater pollution source are more complicated and hence difficult to identify and remediate since it is difficult to locate the origin and areas of impact of the contamination (Raymond , 1979). The aim of the study is to examine the ground water contamination level in Ehime Mbano area of Imo state, south-eastern Nigeria. Water related diseases from subsurface has been reported in the past. Feachem et al. 1998 reported high incidence of water-related diseases in thickly populated settlements with their sources traced to wells. Also Palmer and Holman (1997), observed that chemical pollutants such as heavy metals which constituted cancer and other related illnesses was traced to the underlying ground water from poorly managed waste source in a Delhi city of India. In the strength of these, the assessment of the ground water quality of the study are becomes imperative following the unprecedented population explosion occasioned by the movement of the people to the suburbs due to government policy.

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II. Materials and Method

a) Description of Study Area

Ehime Mbano is located within Anambra / Imo sedimentary basin of South-eastern Nigeria. It is bounded by latitude 5° 37N to 5 °46 N and longitude 7° 14 E to 7° 21E Fig I . The drainage pattern is dendritic typical of sedimentary rock with uniform resistance and homogenous geology (Dever and James, 1985). The area has a tropical climate and experience two air masses, equatorial maritime air masses , associated with rain bearing South-

Table-I Stratigraphic Sequence In South-Eastern Nigeria (Reyment 1965)

Neogene	Recent Miocene-Pieostocene	Marine deltaic deposits; alluvium Benin Formation	
	Oligocene ? - Miocene	Ogwashi-Asaba Formation	
Paleogene	Ledian	Not represented	
	Bartonian	Possibly upper part of Ameki Formation	
	Lutetian	Ameki Formation	
	Ypresian	Possibly lower most part of Ameki Formation	Nanka sand
	Paleocene	Imo Shale	
Upper Cretaceous	Danian	Nsukka Formation	
	Maestrichtian	Ajalli Sandstone	
		Mamu Formation	
	Campanian	Enugu Shale	Nkporo shale
	Coniacian-Santonian	Awgu Shale	
	Turonian	Eze-Aku Shale	
	Cenomanian	Odukpani Formation	
Lower Cretaceous	Albian	Unnamed Formations	“Asu River Group”
		Abakaliki Shale	

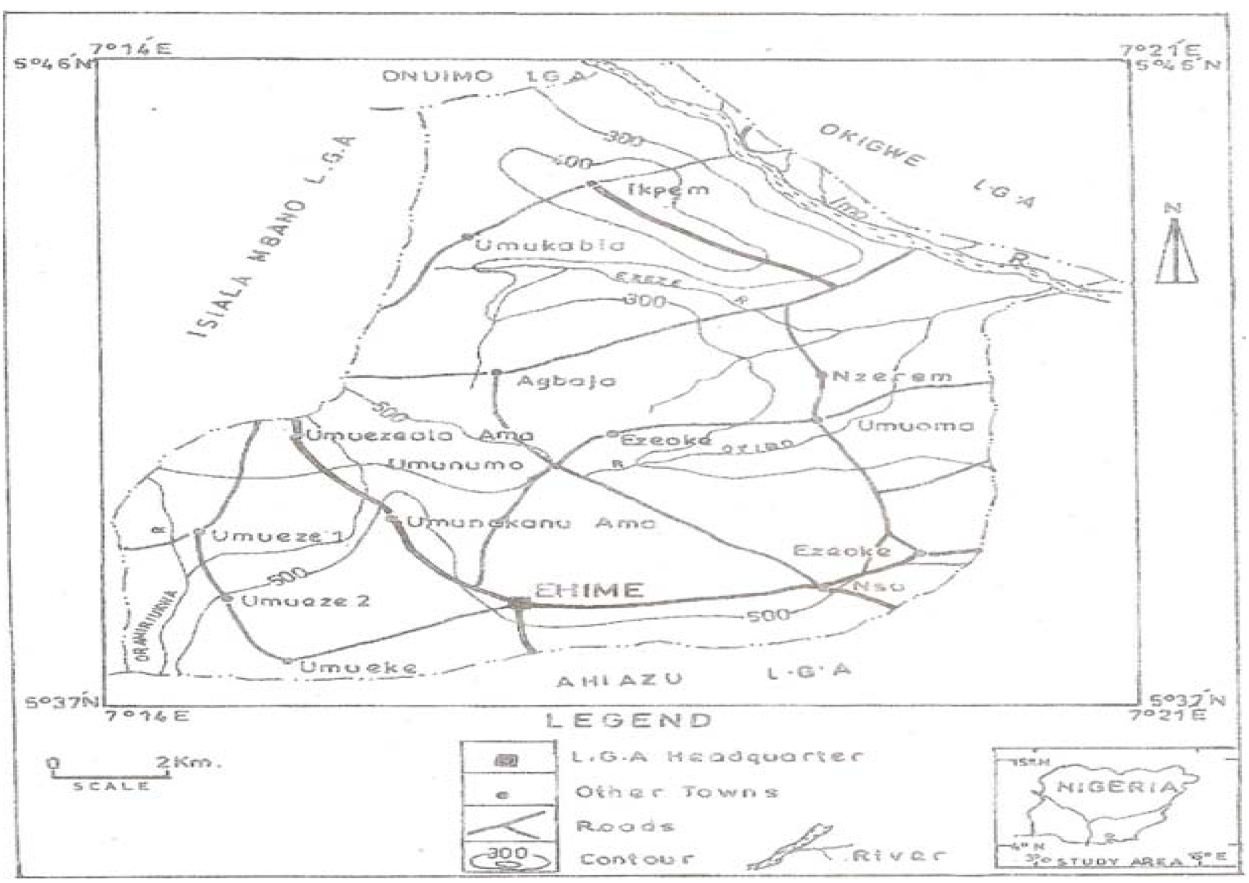

Fig. 1: Topographical Map of the Study Area

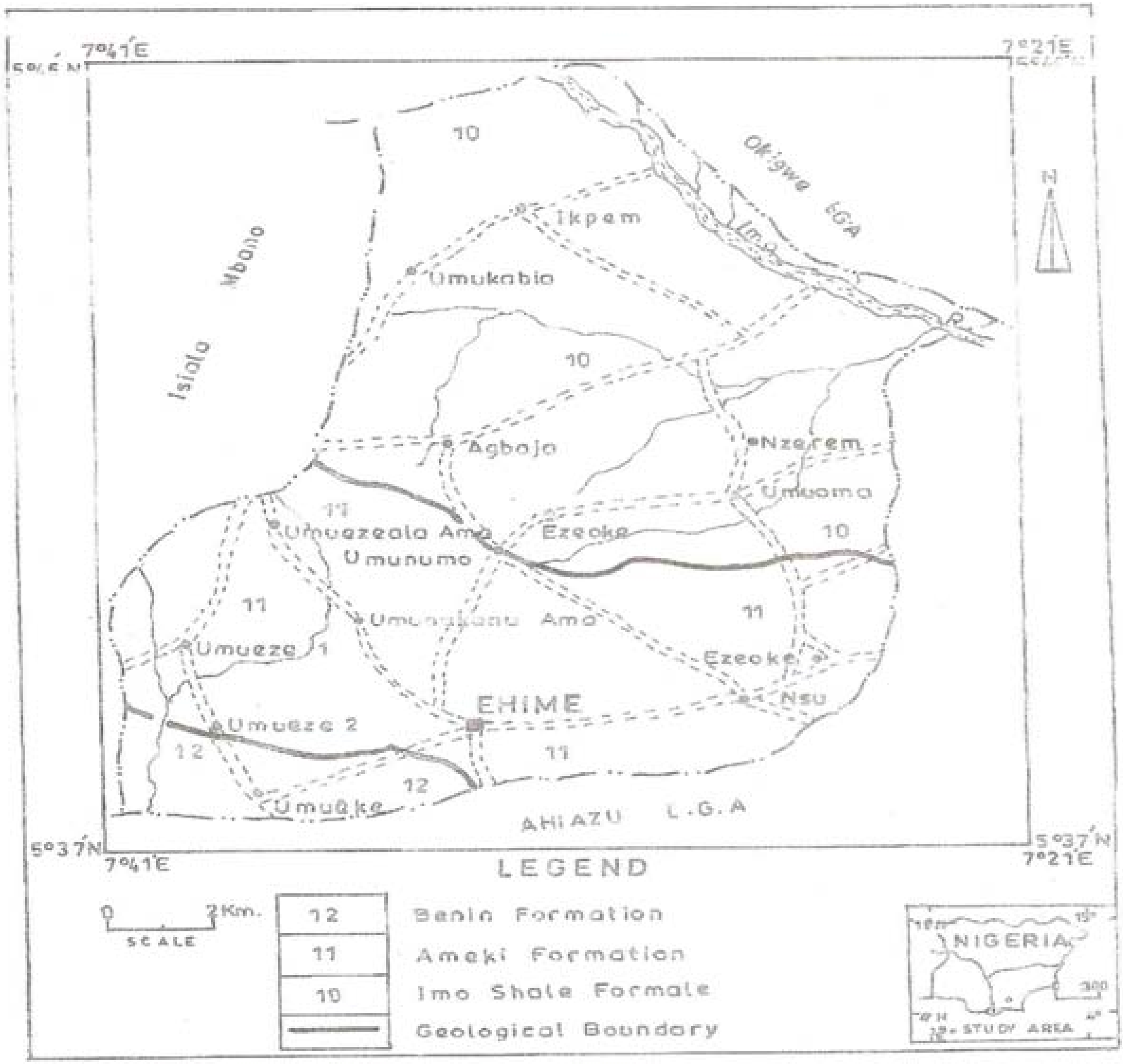

Fig 2: Geological map of the study area

West winds from Atlantic ocean around March to September (Illoeje 1981). The other is dry and dusty hamattan wind from Sahara desert blowing around December to February. The annual total average rainfall is about 230mm while temperature ranges from 29 °C during dry season to about 33°C in rainy season . Relative humidity lies between 65% and 75% (Illoeje 1981).

The physiography is dominated by a segment of Northern , South eastern trending Okigwe regional escarpment which stands at elevation of between 61m and 122m above sea level (Alfred 1992). Vegetation in the area is tropical rain forest which is prevalent in the Southern states of Nigeria (Oguntoyimbo, 1987). Due to great demand of land in the area coupled with other human activities especially over grazing, the rain forest has been replaced by some economic crops such as oil palm forest.

The soil of the area is loamy with scattered pebbles (Gorrel, 1990). Thick vegetative covers has prevented soil erosion , however, erosion is prominent in the areas where road cuts, forest clearing and over cropping have opened up the soil to erosion elements (Stephen 2004). The presence of Benin Formation is a contributory factor to soil erosion especially where they are exposed unprotected by vegetation (Onunkwo –Akunne and Ahiarakwem 2001). Ehime Mbano and environs falls within Anambra –Imo sedimentary basin of South-eastern Nigeria and is underlain by Benin Formation (–miocene – recent) (youngest) Ameki Formation (Eocene) and Imo Shale Formation (Paleocene) and oldest in the area fig 2 and table 1. The major aquiferous formation is Benin Formation (Parkinson, 1970).

b) Data Collection

Data was acquired from field work, laboratory investigations and libraries. Topographic and geologic

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maps on a scale of 1: 250,000 was obtained from Nigeria geological survey department, Enugu. Spring out crops, geological boundaries landuse especially waste dump sites were visited and examined.

A total of 6 water samples were collected for organic and inorganic analysis Analysis was carried out using Atomic absorption spectroscopy for Ca^{2+}, Na^{+}, Mn^{2+}, Cl^{-} , Pb, Cd, Zn and Cu were analyzed with the aid of spectrophotometer while K+ was determined using flame photometer method. pH was measured with standard pH meter while the concentrations of total Iron (Fe) were determined calorimetrically using Spekker absorption meter. Total dissolved solids (TDS) was determined using glass fiber filter. The concentrations of Ca^{2+}, Mg^{2+} and Na^{+} in milli equivalent / litre were used to obtain sodium absorption ratio (SAR).Turbidimetric method was used to assess turbidity. Physical parameters like pH and dissolved oxygen were measured insitu in the field with the appropriate standard meters. While anions like HCO_3 were estimated by titrimetric method. All details of analytical procedures are reported in Omidiran (2000). Clean plastic containers were used to contain the water samples. They were rinsed several times with the same water samples to be analyzed , then covered with air tight cork and carefully labeled and sent to the laboratory for analysis, within 24 hours of collection. The parameters analyzed are Temperature, dissolved oxygen, turbidity, conductivity, total dissolved solid iron (Fe^{2+}) Calcium (Ca^{2+}) Chloride (Cl^{-}), bicarbonates ($HCO3^{-}$), total hardness and Sodium (Na^{+}) etc. Coliform count was analyzed as to estimate possible bacteria presence. Physical parameters such as oxygen, pH , conductivity and temperature were measured insitu in the field.

III. Results and Discussion

The result of water analysis of the 6 water samples compared with WHO (1984) standard guidelines for acceptable water standard is shown in table 2 .

Table 2 Result of water analysis

Parameters	S1	S2	BH_1	BH_2	BH_3	BH_4	Average	WHO (2004)	LEGEND
Sodium (Na^{+})	1.83	1.64	0.80	0.82	0.54	0.71	1.05	< 200	S1 Umuofor
Potassium (K^{+})	3.30	3.41	1.11	2.13	2.01	0.94	2.15	< 50	Ezeoke Nsu Stream/Spring
pH (at 29°C	7.20	7.01	6.80	6.90	6.80	6.70	6.90	6.50-8.50	S2 Umualumaku
TDS	28.56	21.03	7.40	12.54	9.03	7.45	14.3	<1000	Stream/Spring
Calcium (Ca^{2+})	9.64	8.02	3.68	2. 73	4.81	5.03	5.65	<50.00	BH1 Umualumaku
Magnesium (Mg^{2+})	6.41	3.99	1.35	1.68	2.82	3.00	3.21	<50.00	Alaili Borehole
Total Hardness	16.05	12.01	5.03	4.41	7.63	8.03	8.86	<250.0	BH2 Umuakanusi , Borehole
Chloride (Cl^{-})	4.05	5.10	3.01	2.42	3.60	2.81	3.50	<5.0	BH3 Umueze I
Conductivity (ms)	26.80	24.40	5.01	12.40	7.03	6.62	13.7	<2000	Borehole
Phospahte (PO_4^{2-})	7.70	6.34	2.13	2.00	1.64	1.90	3.62	<10.0	BH3 Umueze I
Iron (Fe^{2+})	0.019	0.080	0.480	0.210	0.060	0.36	0.20	<0.30	Bore hole
Carbonates	16.41	14.00	8.01	6.33	8.14	6.82	9.95	<250.00	*BH_4 Umelekezala Borehole
Turbidity (NTU)	23.40	21.41	15.01	15.63	14.50	15.04	17.5	< 5	
Nitrates (NO_3^{-})	1.26	1.34	1.20	1.11	0.39	1.21	1.09	< 5.00	
Sulphate (SO_4^{2-})	3.61	2.93	2.10	1.40	1.63	2.00	2.28	< 250.0	

The average pH value of the six water samples is 6.90 which indicates a slightly acidic condition. The average value of total dissolved solids (TDS) is 14.33. The principal constituents of TDS are chloride, sulphate , calcium, magnesium and bicarbonate. Sodium content was used to classify water quality for irrigation purpose because of its reaction with soil to reduce the permeability

(Etu Efeotor, 1981). Thus, the relation sodium absorption ratio

$$SAR = \frac{Na^{+}}{(Ca^{2+} + Mg^{2+})\ ½} \quad (meq/L) \ldots\ldots\ldots\ldots(1)$$

was employed to determine the suitability of the water for irrigation purpose. According to Etu Efeotor 1981, water class based on SAR is classed as 0-10-excellent, 10-18-Good, 18-26 fair while > 26 is poor. Using equation 1, the SAR for components derived from table 3 for S_1 , S_2, BH_1, BH_2, BH_3 and BH_4 are 0.1121, 0.1181, 0.09, .07, 0.964 and .0484 respectively indicating that the water is excellent for agricultural purposes (Etu-Efotor 1981). From Table 2 the average values in mg/L of Ca^{2+}, mg^{2+}, K^{+}, Na^{+} among others are 5.65, 3.21, 2.15 and 1.06, these values conform with standard approved by WHO for portable water indicating that the 6 water samples are acceptable based on WHO scale.

The average proportion of the percentage concentration of anions – SO_4^{2-}, Cl^- and Hco_3 also stood at 2.8 mg/l, 3.50 mg/l and 9.95 mg/l. these also conform with acceptable standard of WHO guidelines. The result of the conversion of the relevant cation and anion to milliequivalent per litre in shown in table 3

Table 3 Anion and Cation concentration to miliequivalent per litre.

CATIONS

Component	Conc	Atomic	Charge	Equiv	Conc	% of
Cations	Mg/l	Weight	≠	Mass (EM)	Mg/l	Component
Ca^{2+}	5.65	40.08	2	20.40	.2819	43.56
Mg^{2+}	3.21	24.31	2	12.156	.2641	40.81
Na^+	0.06	22.98	1	22.989	.0461	7.12
K^+	2.15	39.10	1	39.102	.0550	8.51
		Total			0.647	100
ANIONS						
Hco_3^-	9.95	61.02	1	61.02	.1658	
No_3^-	1.09	62.0	1	62.0	.0176	
$So_4 2^-$	2.28	96.06	2	48.03	.0475	
Cl^-	3.50	35.45	1	35.5	.0981	
		Total			.3296	100.002

Table 3 was employed to construct pipertrilinear plot as to assess the water class and portability. From fig3, the water plots within a calcium and bicarbonate type and also plots on the left side of the diamond shape of the pipers plot indicating a fresh water. Cation and anion relation in milliequivalent per metre shows that the basic cation constituents are in the following order

$Ca^2+ > Mg^2+ > Na^2+ + K+$. For the anion values the relation holds as $Hco_3 > cl- + No_3- > So4^2-$. This indicates the dominance of calcium and bicarbonate, giving rise to CaHCO3 water.

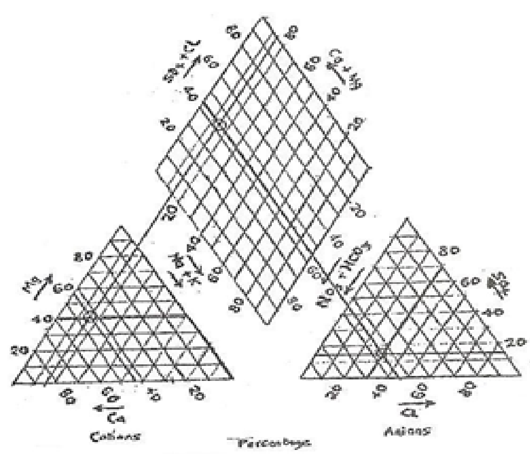


Fig. 3 Piper's Trilinear plot (1944)

The result of biochemical analysis is shown in table 4. It shows the examination of the total coliform count that indicates absence or presence of bacteria in water (Martin 1977).

Table 4 Bacterial analysis of the Six Water Samples

Sample	Total Hetertropic plate count	Dilution	Organism	Faecal coliform count	Faecal stereoto coccii	E.coli count	cl. Welchi count
S_1	95	10^2	9.5×10^2	-	-	-	-
S_2	80	10^2	8.0×10^2	-	-	-	-
BH_1	75	10^2	7.5×10^2	-	-	-	-
BH_2	18	10^2	1.8×10^2	-	-	-	-
BH_3	24	10^2	2.4×10^2	-	-	-	-
BH_4	25	10^2	2.5×10^2	-	-	-	-

The result of the organic analysis of the ground water samples of table 4 indicates that there were no faecal coliform found in the water samples, therefore no pathogens in the water. On the whole, the high values of turbidity may be due to sediments from erosion and algae growth, urban runoff and flooding as a result of climatic change (Offodile 1988). The high level of iron (Fe2+) could be as a result of corrosion of steel pipes (Barnes and Clarke 1980). The possible effect of high iron are red or yellow strining of laundry and house hold fixtures (Palme et al 1997). The possible health effects are high concentration of iron stored in the pancreas, livers, spleen (Oteze 1991). High concentration of iron in the body can cause liver and lung problems (Offodile, 1987). From the piper plot, the ground water in Ehime Mbano and environs is portable and of calcium bicarbonate type (CaH Co3)

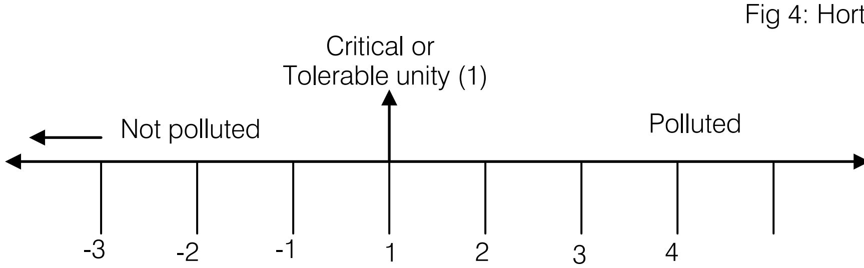
The comparison of chemical analysis of Ehime Mbano subsurface water with American water works association standard (1991) for industrial water is shown in table 5

Table 5 Ground water analysis result from Ehime Mbano area compared with American water works Association (1991) (AWWA) standard for industrial water.

Parameters	Average value of sample analyzed	AWWA (1991) accepted standard
TdS	14.3	50-1, 500mg/l
Toral hardness	8.66	0-250mg/l
Iron (Fe+)	0.20	0.1-1.0mg/l
PH	6.90	6.5-8.3
Chlorides	3.50	20-250mg/l
Manganese	-	0-0.5mg/l

With reference to table 5, the groundwater in the area should be treated for iron before they are used for some industries eg. Laundry. In employing the pollutional index scale of Horton (1995), it is possible to calculate the pollution index of the area as to assess the extent of pollution. The Horton scale is shown in fig 4 .

Fig 4: Horton scale (1995)



Unity value of (1) indicates a tolerable standard, but above this value (1) the water is polluted and below this (1) the water is not polluted. The pollutional index is calculated using the formular propounded by Horton (1995) as shown in table 6.

The pollutional index of S1 is calculated as in table 6

Table 6 Computation of pollution index of S1

Parameter mg/l	Ai	Wij	Ai/Wij
pH at 29^0C	7.20	6.5-8.5	0.960
Turbidity (NTU)	23.40	5.0	4.680
Conductivity (MS)	26.80	100	0.268
TDS	28.56	500	0.057
Iron (Fe+)	0.019	0.3	0.063
Calcium Ca^{2+}	9.64	75	0.129
Magnesium mg^{2+}	6.41	<30	0.214
Potassium (K^+)	3.30	200	0.017
Sulphate ($So4^{2-}$)	3.61	250	0.014
Phosphate ($Po4^{2-}$)	7.70	-	-
Nitrate (No_3^-)	1.26	10	0.126
Chloride (Co_3^{2-})	16.41		
Total Ai/Wij			0.5953
Total parameter			6.584

Mean Ai/Wij = 0.5953

Max Ai/Wij = 4.080

Pollution index Piji =

$$\sqrt{\frac{(Max^2 + Ai + Wij)^2 + (Mean\ Ai + Wij)^2}{2}} \quad \ldots (2)$$

$$\sqrt{\frac{(4.680)^2 + 0.5953)^2}{2}} = 3.336$$

In the same way the pollutional index of the other water samples S1 S2 BH1 BH2 BH3 BH4 are 3.336, 3.05, 2.155 2.156, 2.156 and 2.21. The total average for the six water samples gives 2.501. this value shows that the Ehime Mbano ground water is slightly polluted having a value of 2.50 which exceeded the critical and tolerable limit of unity (1) (Horton 1995)

The pollutional index of 3.336 within Nsu area (S1) shows that Ezeoke Nsu axis is the most polluted in Ehime Mbano NE area. The suitability of water for domestic purposes is based on total hardness, total dissolved solids (TDS) and portability (Davis and Dewest, 1996). The average value 8.86mg/l for total hardness and 14.3mg/l for TDS indicates that the water belongs to fresh and soft class. (Hem 1970, Carrol, 1962). The water therefore has no laxative effects (Oteze, 1991). The ground water in the area is slightly acidic (6.90). Acid level in water is an indication that there will be more of reduction than oxidation. (Raymond 1979). This implies dissolution of metals leading to high TDS and consequent destruction of metal pipes. High pH causes bitter taste, while water, using appliances become encrusted (Hem, 1970). A comparison of the chemical result of the 6 water samples to American water works association (1991) shows that iron (fe2+) is 0.1 – 1.0 mg/l, mn2+ (20 – 250mg/l), total hardness as Caco3 (0 – 250mg/l, pH (6.5 – 8.3), chlorides (20 – 250mg/l) and TDS 50 – 1500mg/l). This indicates that ground water in the study area is suitable for use in most industries. From the organic analysis carried out, there were no bacteria presence in water. Thus the water can be consumed without fear of water borne diseases.

IV. Conclusion and Recommendation

In conclusion, the exploratory survey of the geochemical aspects of underground water in Ehime Mbano shows that the water has high turbidity, high iron, slightly acidic soft and suitable for domestic, industrial and irrigation purposes. Above all the water has no laxative effect and no bacterial presence (hence no water borne diseases). Pollutional index of Horton indicates slight pollution. The pollutional index of 3.336 within Ezeoke Nsu shows that the NE section of Ehime Mbano is most polluted.

To solve the minor problems of water standard, in the area, high turbidity can be solved by distillation and filtration. Problems of High iron can be solved by aeration, while the pH can be elevated slightly using alkaline fertilizer.

Borehole owners should be encouraged to test their water periodically. Water chemistry examination should be carried out seasonally, since groundwater is subject to surface geological changes (Offodile, 1987). Government should standardize the activities of various water agencies and drilling companies and ensure strict compliance to specified methods of water borehole construction. Water treatment facilities should be made available and accessible to the public. There should be good public orientation and awareness programme, enlightening the masses on the importance of portable water quality standards as well as the adverse effects of contaminated water.

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Experimental Investigation of Microbial Contamination of Nano Cutting Fluids with Cnt Inclusion

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Abstract- The use of cutting fluids in machining is indispensible. However, the microbial contamination of the fluids limits their usage. In the present work nano cutting fluids with carbon nano tube (CNT) inclusion are prepared for use in Minimum quantity lubrication (MQL). Microbial contaminations of these samples are analyzed along with the fluids under stored condition over a span of one month, and the bacteria present in the fluid is isolated and identified to help provide the appropriate remedial actions.'

Keywords: Minimum quantity lubrication; cutting fluids; microbial contamination; pseudomonas.

Classification: GJRE-C Classification: FOR Code: 860603, 270399

EXPERIMENTAL INVESTIGATION OF MICROBIAL CONTAMINATION OF NANO CUTTING FLUIDS WITH CNT INCLUSION

Strictly as per the compliance and regulations of:

Experimental Investigation of Microbial Contamination of Nano Cutting Fluids with Cnt Inclusion

S.Narayana Rao[α], Dr.B.Satyanarayana[Ω], Dr.K.Venkatasubbaiah[β]

Abstract- The use of cutting fluids in machining is indispensible. However, the microbial contamination of the fluids limits their usage. In the present work nano cutting fluids with carbon nano tube (CNT) inclusion are prepared for use in Minimum quantity lubrication (MQL). Microbial contaminations of these samples are analyzed along with the fluids under stored condition over a span of one month, and the bacteria present in the fluid is isolated and identified to help provide the appropriate remedial actions.'

Keywords: minimum quantity lubrication; cutting fluids; microbial contamination; pseudomonas.

I. Introduction

The prime function of cutting fluids stands is to provide adequate lubrication and cooling in metal cutting operations [1]. In addition, the fluids decrease adhesion between chip and tool and thus the adhesion wear. Lubrication also induces chip curl by reducing the rake contact length. Further, the fluids wash away the chips and keep the cutting region free.

Cutting fluids must offer some degree of corrosion protection. Freshly cut ferrous metals tend to rust rapidly because protective coatings have been removed by machining operation. A good metal working fluid inhibits rust formation avoiding damage to machine parts and the workpiece.

The coolant of the fluid prevents thermal expansions of the workpiece. Consequently, the fluids help in achieving longer tool life and better surface finish of the product. These benefits made the existence of the fluids in metal cutting operations for the last 200 years.

There are now several types of cutting fluids in the market, the most common of which can be broadly categorized as cutting oils or water-miscible fluids. Water-miscible fluids, including soluble oils, synthetics and semi synthetics, find 80 to 90 percent applications.

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Though cutting fluids have been looked upon as solution to reduce friction and temperatures in metal cutting, their usage is limited due to the various environmental and health hazards associated of the several problems associated, skin diseases caused to the workers, problems due to mist generation and used oil disposal deserve greater concern. Skin problems include mechanical trauma to the skin, infections, oil acne, folliculitis and irritant and allergic dermatitis [2, 3]. Small cuts to the skin from metal shavings are common. These cuts can become infected as a result of contact with the fluids contaminated with microbial organisms. Basically, the microorganisms that develop in cutting fluids may be categorized as aerobic bacteria, anaerobic bacteria and fungi. Aerobic bacteria are extremely oxidative and adapt well to the wide variety of organic molecules found in cutting fluids. Their growth leads to emulsion separation, loss of lubricity qualities and corrosion. Cutting fluids cause skin diseases to the workers who are constantly exposed to them. Skin exposed to contaminated cutting fluids results in folliculitis. Workers also become vulnerable to other skin diseases like mechanical trauma to the skin, infections, oil acne and allergic dermatitis associated with the use of cutting fluids [4, 5]. The primary microbial species commonly found in the cutting fluids belongs to the genus Pseudomonas [2]. This group has the reputation of being difficult to kill, having the broadest appetite and least nutritional requirement among any group of microorganisms. It may be noted that this bacteria is prevalent even in biocides used in hospitals. These organisms are highly oxidative, i.e. they grow best under conditions of maximal aeration, multiplying typically every 45 minutes under ambient conditions of the fluid. This bacteria being highly opportunistic, is non-invasive, but causes infection through any open cuts or wounds those are common in a workshop.

In the present work, microbial contamination of the fluids was studied for stored samples of the cutting fluids since in MQL there is no question of recirculation of the fluid. The samples were stored in air-tight sterilized bottles and samples were tested weekly once.

II. Experimentation

Cutting fluid samples with 0.5, 1, 2, 3, 4, 5% carbon nano tube inclusion were prepared to be used in Minimum Quantity Lubrication (MQL). To quantify microbial contamination, plate count method was adopted in the present work. Petri plates with nutrients needed for the growth of bacterial colonies were used for the purpose. In the present work, petri plates of nutrient agar (Fig.1) were used [6].

Fig. 1 Petri plate

The choice was made based on the aerobic nature of the bacteria. 0.1 ml of samples of cutting fluids were collected every week in a petri plate under laminar air flow. While transferring the fluid samples to the Petri plates, the samples are vulnerable to the bacteria present in air. To prevent contamination from air, the transfer of collected samples into the petri plates was done in a laminar air flow cabinet (Fig.2) in the presence of a blue flame. The sample was incubated in a B.O.D incubator (Fig.3) at 37 0C for 24 hours. The number of colonies was counted after incubation. The test was carried out in triplicate for higher reliability of results.

Fig. 2 Laminar air flow cabinet

Fig. 3 B.O.D. Incubator

For identification of the bacterial species, the process was repeated using petri plates of different nutrients and other common tests like oxidase test were carried out.

III. Results & Discussions

Microbial contamination is one of the limiting factors in using cutting fluids. Several skin diseases in the workers are associated with the use of contaminated fluids. Growth in microbial contamination of the fluids was measured in the samples. Colony growth was observed colonies were observed (Fig. 4) for the samples. The samples were collected once in a week for four weeks.

Fig. 4 Colony growth in samples

Fig. 5 represents the results (number of colonies) obtained from plate count of the stored samples, with different CNT contents.

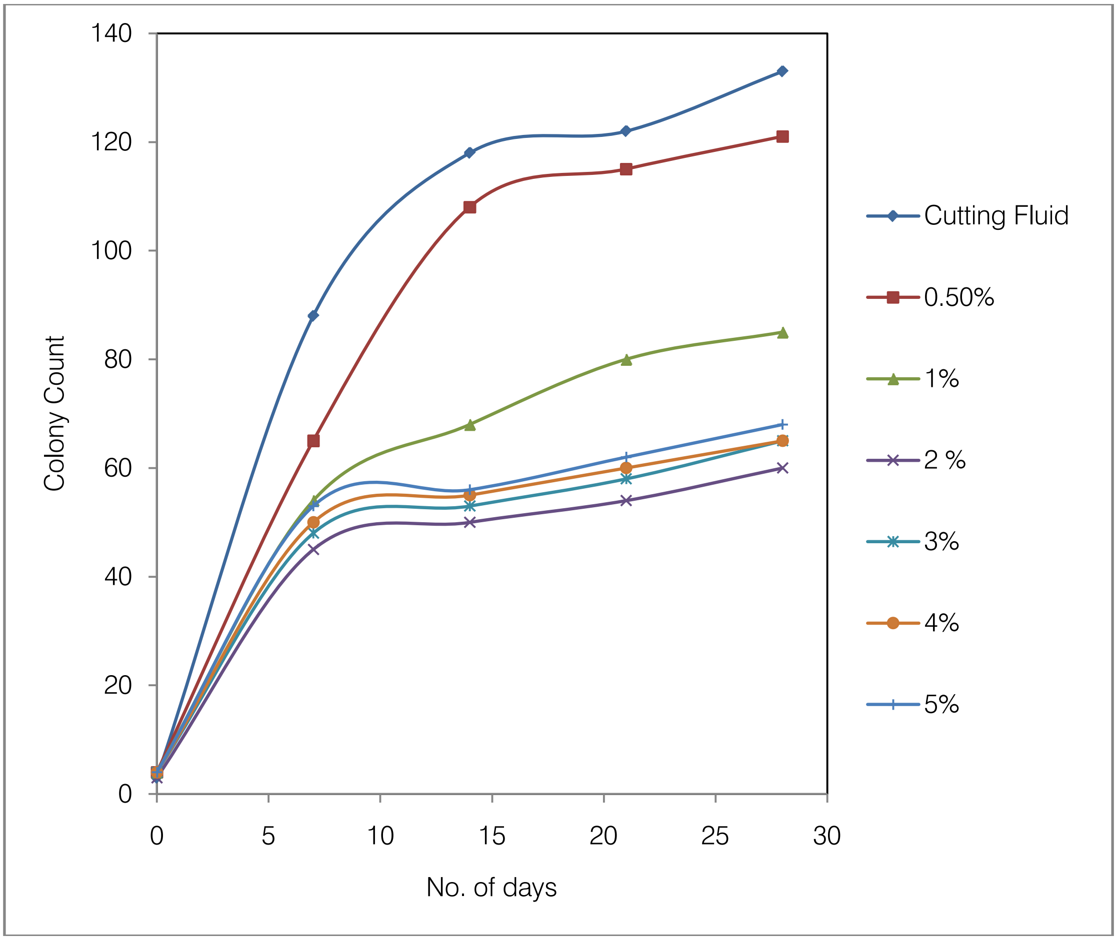

Fig. 5 Microbial growth in samples

The results indicate least growth of microorganisms in sample with 2% inclusion. This may be attributed to the reason that the pH value of 2% inclusion is more hostile to the bacteria compared to 0%, 0.5% and 1% CNT fluids, but contains lesser nutrients to the microorganisms compared to 3%, 4% and 5% CNT fluids. Since excess CNT does not disperse well, it does not affect microbial growth.

In order to estimate the effect of the microorganism present in the fluid and decide on the remedial actions, identification of the organisms is mandatory. Isolation is done and the organism is tested in various culture media and the results are presented in Table 1. As growth is observed only in cetrimide agar that is specific for Pseudomonas, the results lead to an inference that the organism present in samples is Pseudomonas genus.

Table 1 Identification of bacterial species

Experimental Procedure	Observations	Inference
Gram Stain	Pink colored rods	G^{-ve}, rods
Agar slant cultural characteristics	Abundant thin white growth	
Fermentation	Lactose – No acid or gas Dextrose – No acid or gas Sucrose – No acid or gas	No fermentation
IMVIC	Indole – No cherry red ring	No tryptophanate enzyme
	Methyred- No red color	No acid formation
	VP- Light red color	Neutral product formation
	Citrate- Blue color formation	Citrate utilized
H_2S test	SIM medium – no black coloration	No H_2S production
Catalase	Bubble formation on addition of H_2O_2	Catalase positive
Oxidase test	Pink color changing to maroon	Oxidase positive
Geletin liquefaction	Geletin liquified	Gelatinase production
Growth in Macconkey medium	No growth	Growth observed only in Pseudomonas specific Cetrimide agar
Mannitol salt agar	No growth	
Cetrimide medium	Growth occurred	

It is noteworthy that in literature, the bacteria in stored samples were identified as Pseudomonas genus. This validates the present work as the results for stored samples are in line with the earlier studies. The genus Pseudomonas consists of aerobic, gram-negative bacilli. Being opportunistic bacteria, Pseudomonas though not invasive, has the tendency to aggravate in case of an injury or burns. There are about seventy species in Pseudomonas, majority of which have the ability to break down the oils (which can crucially affect the cutting fluid). The organisms utilize the carbon present in the oils as their source of nutrition and deteriorate the oil into inorganic compound. Pseudomonas has the ability to survive in hostile conditions and is not suppressed even by biocides (it is common to find Pseudomonas even in hospital disinfectants). Further, the use of biocides in the cutting fluids is subjected to several constraints imposed by the environmental regulations of various organizations. Thus the best way to control the growth of the bacterium would be to optimize the content of CNT inclusion.

IV. Conclusions

1. Bacterial growth was less in fluids with CNT inclusion.
2. 2% CNT fluid showed minimum growth
3. Bacteria was found to be Pseudomonas

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Unit Commitment Scheduling with Wind power generation Uncertainty and Emission Consideration

By Mohadese Bagheri , Majid Shahabi

Abstract- Nowadays, in order to achieve environmental goals, renewable energy sources especially wind, has been seemed useful while wind generation does not directly produce air pollutants emission. So it seems necessary to consider air pollutants emission level in wind-thermal scheduling problems. This paper proposes two methodologies for wind – thermal scheduling in a power system with high penetration of wind power subject to consider air pollutants emission reduction. Also a stochastic programming market-clearing model has been applied for solving unit commitment problem to overcome stochastic nature of power. In this stochastic security model, wind generation uncertainty is modeled by scenario tree in scheduling time horizon. The usefulness of the proposed approach was demonstrated through an IEEE 30-bus test system over 6 hours.

Keywords: Emission, Stochastic Scheduling, unit commitment, wind power generation.

Classification: GJRE-J Classification: FOR Code: 660202, 850509

UNIT COMMITMENT SCHEDULING WITH WIND POWER GENERATION UNCERTAINTY AND EMISSION CONSIDERATION

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I. Introduction

Nowadays because of low cost of energy generation and its environmental advantages, using wind energy in electric power generation, has been seemed useful. On the other hand because of variability and uncertainty of this energy, using it has made some challenges to power-system operators. In order to adjust the unforeseeable nature of the wind power, planned productions and uses in electricity market must be improved during the real operation of the power system.

Because of the stochastic nature of the wind speed, we need to consider the probable considerations in its modeling equations. Without considering the probable issues, scheduled the system will be determined with deterministic security, and because of extra reserve allocation this method will impose extra cost to the system [1]. In this paper stochastic optimization method has been used for system operation scheduling. By using the stochastic security, a balance can be established between the advantages of using the wind power generations – because of its low cost- and increasing the operation cost – because of the necessity of increasing the needed reserve of the system, and also the required reserve level of the system can be determined optimizing. In this method, besides its normal use, system operation planning will be economical for all the probable scenarios. In stochastic method, in order to establish the power balance between generation and consumption for the probable scenarios with low demand, if the cost of involuntary load shedding is low the involuntary load shedding will be used. [2]. Nowadays decrease of production of the air pollutant gases is under consideration as a behavioral pattern in countries industries. So the level of produced gases by plants must be minimized in operation planning of them. Commitment of the wind plants in power generation increases the importance of considering the generating pollution of thermal units. Because on one hand these wits are not producers of the air pollutant gases, but on the other hand the generating pollution curve of the thermal units is in a way that by high decrease in their generating power level, their generated pollution level increases. By increasing the penetration of wind power generation and providing the load by it, power level of the thermal units decreases, (This case is more apparent in low demand or medium demand hours).

Which means the increase in air pollutant gases emission, in this paper, in order to consider the pollutant gases level in power system operation planning, two methods are offered. These methods include a multi – objective optimization method and considering the maximum permissible generating pollution for plants.

Reference [3] has used a stochastic optimization method for planning the units in a power system with the presence of wind plant, also in [1] the Monte Carlo simulation method has been used in order to estimate the required, spinning reserve of the system. Also in [4] a stochastic optimization method has been used for planning the units. In these reference the uncertainty of forecasting the wind and the demand are considered simultaneously. But the generating pollution of the thermal units in scheduling are not considered in any of these references.

II. Model

In the present paper, for considering the pollutant emission by thermal units in power system operation planning, two methods are offered. The first method is to use multi-objective optimization in power system planning; and the goal of this method is to decrease the operation cost of the power system and air pollutant gases emission simultaneously. The second method considers the power system optimization scheduling by use of stochastic optimization with considering the limit of the maximum generation permissible pollution. While the air pollutant gases level is high and this environmental problem is very important, considering the generating pollution of the generating units as a limit seems logical.

a) *The First Method*

Multi- objective optimization the multi- objective optimization method which is used in this paper is the weighting method. This model includes two objectives.

i. *The first objective*

The first objective is the operation cost, and by using stochastic optimization it is the equation (1).

$$F^{\cos t} = \sum_{t=1}^{N_T} EC_t = \sum_{t=1}^{N_T}\sum_{i=1}^{N_G} C_{it}^{SU} + \sum_{t=1}^{N_T} d_t[\sum_{i=1}^{N_G}(a_i P_{it}^{S\,2} + b_i P_{it}^S + c_i) - \sum_{j=1}^{N_L}\lambda_{Ljt}L_{jt}^S + \sum_{i=1}^{N_G}\left(C_{it}^{R^U} R_{it}^U + C_{it}^{R^D} R_{it}^D + C_{it}^{R^{NS}} R_{it}^{NS}\right) + \lambda_t^{WP} P_t^{WP,S}] + \sum_{\omega=1}^{N_W}\pi_\omega\{\sum_{t=1}^{N_T}\sum_{i=1}^{N_G} C_{it\omega}^A + \sum_{t=1}^{N_T} d_t[\sum_{i=1}^{N_G}(a_i P_{Git\omega}{}^2 + b_i P_{Git\omega} + c_i) + \sum_{j=1}^{N_L} V_{jt}^{LOL} L_{jt\omega}^{shed} + V_t^S S_{t\omega}]\} \quad (1)$$

Where EC_t are the expected cost of the system in period t and $C_{it}^{R^U}$, $C_{it}^{R^D}$, $C_{it}^{R^{NS}}$ respectively the offer costs of the up- down, and nonspinning reserves of unit i in period t. Also π_ω is the probability of occurring the scenario ω and d_t is the length of each time period t in the scheduling horizon. We assume that the wind generators are not competitive factors, so they do not offer a cost in the market ($\lambda_t^{WP} = 0$).

ii. *The second objective*

In the second objective, the generating pollution of the thermal units is considered. Are of the most important air pollutants which are generated by thermal units SO_x and NO_x . Generally, the air pollutant gas level which is generated by unit i in the time horizon t , is estimated by the equation (2) [5].

$$E_{i,t}(P_{it}^S) = d_t[\alpha_i + \beta_i P_{it}^S + \gamma_i P_{it}^{S\,2} + \zeta_i \exp(\lambda_i P_{it}^S)]u_{it} \quad (2)$$

Where $E_{i,t}(P_{it}^S)$ is the generating air pollutant level by the unit i in time horizon t. Where the α_i ‘ β_i ‘ γ_i ‘ ζ_i and λ_i coefficients of the air pollutant objective by unit i and d_t is the length of the time horizon t. in this paper regarding the stochastic nature of the case and the planning and pollution level is considered as stochastic planning and also it has considered in each scenario according to the probability of occurrence of each scenario, so the considered pollution is as equation(3):

$$F^{Emission} = \sum_{\omega=1}^{Nw}\pi_\omega \sum_{t=1}^{T}\sum_{i=1}^{NG} E_{i,t}(P_{Git\omega}) = \sum_{\omega=1}^{Nw}\pi_\omega . \sum_{t=1}^{T}\sum_{i=1}^{NG} d_t[\alpha_i + \beta_i P_{Git\omega} + \gamma_i P_{Git\omega}{}^2 + \zeta_i \exp(\lambda_i P_{Git\omega})]\, u_{it} \quad (3)$$

iii. *The objective of the multi- objective optimization, weighting method*

In this method the multi- objective optimization of the objective has been combined by some coefficients and them from the main objective of the optimization.

$$F = Min\{\eta . F^{Cost} + (1-\eta).ECC.F^{Emission}\} \quad (4)$$

Where ECC is the emission control constant, in $\$/ton$ unit. This constant is used for the cost of operation and the pollution and in fact, if is the cost of controlling the pollution. Also $0 \le \eta \le 1$ is a compromise factor.

b) *Model limitations*

The limitations of the model are categorized in 3 general categories:

i. *Operation limits related to the normal mode operation.*

1. *Market Equilibria*

$$\sum_{i=1}^{N_G} P_{it}^S + P_t^{WP,S} = \sum_{j=1}^{N_L} L_{jt}^S, \forall t. \quad (5)$$

2. *Production limits*

$$P_i^{\min} u_{it} \le P_{it}^S \le P_i^{\max} u_{it}, \forall i, \forall t. \quad (6)$$

3. *Wind generation limits*

$$P_t^{WP,\min} \le P_t^{WP,S} \le P_t^{WP,\max}, \forall t. \quad (7)$$

Where, $P_t^{WP,\max}$ and $P_t^{WP,\min}$ are parameters offered as part of the wind producer energy offer.

4. *Demand Bounds*

$$L_{jt}^{S,\min} \le L_{jt}^S \le L_{jt}^{S,\max}, \forall j, \forall t. \quad (8)$$

Where $L_{jt}^{S,\max}$ and $L_{jt}^{S,\min}$ are parameters submitted as part of the demand-side bids.

5. *Scheduled Reserve Determination Constraints*

a. *Spinning*

$$0 \le R_{it}^{U} \le R_{it}^{U,\max} u_{it}, \forall i, \forall t. \quad (9)$$

$$0 \le R_{it}^{D} \le R_{it}^{D,\max} u_{it}, \forall i, \forall t. \quad (10)$$

b. *Non-spinning*

$$0 \le R_{it}^{NS} \le R_{it}^{NS,\max} (1-u_{it}), \forall i, \forall t. \quad (11)$$

6. *Start-Up Cost*

$$C_{it}^{SU} \ge \lambda_{it}^{SU} (u_{it} - u_{i,t-1}), \forall i, \forall t. \quad (12)$$

$$C_{it}^{SU} \ge 0, \forall i, \forall t \quad (13)$$

ii. *Operation limits related to planning in each scenario this part of the relationships includes actual system operation (second- stage variables)*

1. *Power Balance constraints*

a. *Power Balance at Every Node n (Different from node n' at which the wind power is injected.*

$$\sum_{i:(i,n)\in M_G} P_{it\omega}^{G} - \sum_{j:(j,n)\in M_L} (L_{jt}^{S} - L_{jt\omega}^{shed}) - \sum_{r:(n,r)\in\Lambda} f_{t\omega}(n,r) = 0, \forall n \ne n', \forall t, \forall \omega. \quad (14)$$

b. *Power balance at node n' at which the wind power generation is injected.*

$$\sum_{i:(i,n)\in M_G} P_{it\omega}^{G} - \sum_{j:(j,n)\in M_L} (L_{jt}^{S} - L_{jt\omega}^{shed}) + P_{t\omega}^{WP} - S_{t\omega} - \sum_{r:(n,r)\in\Lambda} f_{t\omega}(n,r) = 0, n = n', \forall t, \forall \omega. \quad (15)$$

c. *Power flow through line from n to r*

$$f_{t\omega}(n,r) = \frac{P_{t\omega}^{loss}(n,r)}{2} + B(n,r)(\delta_{nt\omega} - \delta_{rt\omega}), \forall (n,r) \in \Lambda, \forall t, \forall \omega. \quad (16)$$

2. *Generation Limits*

$$P_{it\omega}^{G} \ge P_{i}^{\min} v_{it\omega}, \forall i, \forall t, \forall \omega. \quad (17)$$

$$P_{it\omega}^{G} \le P_{i}^{\max} v_{it\omega}, \forall i, \forall t, \forall \omega. \quad (18)$$

3. *Transmission Capacity Constraints*

$$-f^{\max}(n,r) \le f_{t\omega}(n,r) \le f^{\max}(n,r) \quad (19)$$

The positive or negative power flow through the lines is related to the different directions of the power flow through a line.

4. *Involuntary Load Shedding Constraints*

$$0 \le L_{jt\omega}^{shed} \le L_{jt}^{S}, \forall j, \forall t, \forall \omega. \quad (20)$$

5. *Limits of Wind Power Generation Spillage*

$$0 \le S_{t\omega} \le P_{t\omega}^{WP}, \forall t, \forall \omega. \quad (21)$$

iii. *Constraints linking the normal model and scenario scheduling*

1. *Decomposition of Generator Power Outputs:*

$$P_{it\omega}^{G} = P_{it}^{S} + r_{it\omega}^{U} + r_{it\omega}^{NS} - r_{it\omega}^{D}, \forall i, \forall t, \forall \omega. \quad (22)$$

2. *Deployed Reserve Determination Constraints:*

a. *Spinning*

$$0 \le r_{it\omega}^{U} \le R_{it}^{U}, \forall i, \forall t, \forall \omega \quad (23)$$

$$0 \le r_{it\omega}^{D} \le R_{it}^{D}, \forall i, \forall t, \forall \omega \quad (24)$$

b. *Non-spinning*

$$0 \le r_{it\omega}^{NS} \le R_{it}^{NS}, \forall i, \forall t, \forall \omega \quad (25)$$

c. *Second-Stage Start-Up Cost Adjustments:*

$$C_{it\omega}^{A} = C_{it\omega}^{SU} - C_{it}^{SU}, \forall i, \forall t, \forall \omega \quad (26)$$

$$C_{it\omega}^{SU} \ge \lambda_{it}^{SU} (v_{it\omega} - v_{i,t-1,\omega}), \forall i, \forall t, \forall \omega \quad (27)$$

$$C_{it\omega}^{SU} \ge 0, \forall i, \forall t, \forall \omega \quad (28)$$

Note that variable $C_{it\omega}^{SU}$ accounts for the start – up cost incurred by generating unit i during the actual operation of the power system in period t and scenario ω. The important advantages of the planning with stochastic security are planning with the goal of minimizing the operation cost and the pollution in normal mode and in all scenarios [3].

c) *The Second Method*

The emission of the maximum permissible pollutant gases by each generating unit is considered in this method, for more about, In this method the stochastic planning objective includes the operation cost in normal mode and in each scenario, which is the cost objective of the equation (1). As it is mentioned, in this method each generating unit depending on the climate and environment is allowed to generate only a particular amount of pollution. This permissible pollutant emission can be modeled as the following equation.

$$\sum_{t=1}^{T} E_{i,t}(P_{it}^{S}) \le E_i^{target}, \forall i. \qquad (29)$$

Where E_i^{target} is the permissible amount of generating pollution of unit i during the expected horizon. The time horizon of considering the pollution limits is weekly or monthly. Other limits will be similar to the limits of section (2.2).

III. Case Study

The system which is being studied in this paper is the IEEE 30- bus system [6]. It is assumed that the wind plant is located in a 22 bus system. This system consists of six generators and their data have been extracted from the reference [6]. This planning is tested over a 6-h scheduling horizon. The general hourly demand in 6-h scheduling has been considered 450,420,200,150,120 and 100MW. The prediction of the hourly wind shown in table 1. Just three wind power scenarios are considered: as forecast, high and low, with probabilities 0.6, 0.2, and 0.2, respectively. Modeling the wind prediction in 6 hours has been considered a scenario tree-Also in order the conducted planning has not been considered. And also in order to access to a better answer, by using the integer linear programming, the non linear parts of the objective has became linear by a linearing method. The expected model has been coded and performed by using the mixed integer linear programming in the powerful GAMS software [7].

Table 1: Wind Power Scenario

Period t	$P_{t\omega}^{wp}(MW)$		
	As forecast	High	Low
1	60	80	40
2	80	100	60
3	70	90	50
4	80	100	60
5	70	90	50
6	80	100	60

In order to analyze the results, the units generating costs and the pollutant emission of each unit curves are presented in Fig (1). In order to note the importance of considering the pollutant emission in operation scheduling, planning with the goal of minimizing the system operation cost has been performable separately and these results have been compared with the results of the offered methods. The results of the system planning with the goal of minizing the operation cost have been estimated in table (2). As it can be seen in this table, to provide the required power of the system, units with lower cost offering are in priority for power providing. Tables 3 and 4 , respectively, show the results of the planning's at which the units generating pollution level is considered as a limit and the multi- objective planning is applied in a weighting method. The amount of the maximum generating pollution in the time horizon of planning for am generators is similar and is equal to 0.17 ton. Also in multi- objective optimization method is considered as $\eta = 0.6$. As it is seen in table 3, results of this kind of planning have been changed. One of these changes in decrease of the number of unit 4(unit with the cheapest objective of offering energy). It is obvious that, this change is because of limiting the permissible generating pollution of the u nits during the scheduling horizon.

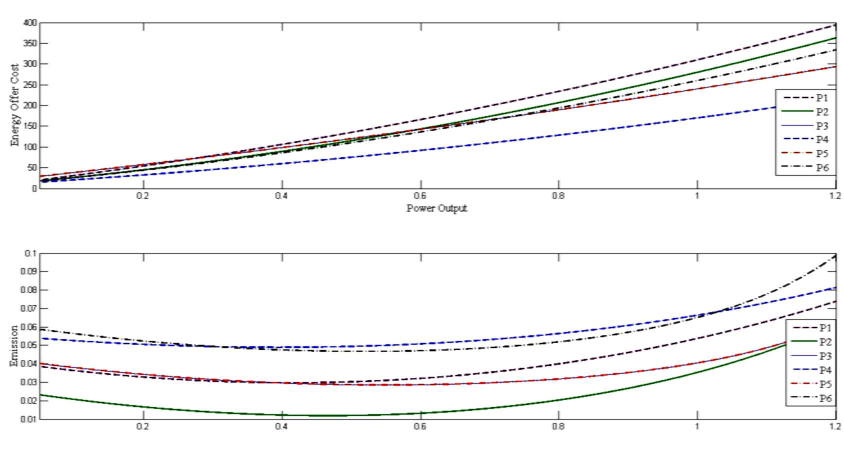

Figure 1- Out Put Power And Units Generating Pollution Curves.

Table 2- Results of System Planning With the Goal of Minimizing the Operation Cost

t	1			2			3			4			5			6		
generators	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D
1	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	54	0	0	48	0	0	32	0	0	0	0	0	0	0	0	0	0	0
3	95	5	5	95	5	5	0	0	0	0	0	0	0	0	0	0	0	0
4	92	0	0	88	0	0	61	0	7	55	0	6	51	0	10	40	0	12
5	57	8	6	57	8	7	0	0	0	0	0	0	0	0	0	0	0	0
6	52	7	0	52	7	0	37	20	0	15	20	0	5	14	0	0	0	0
$P_t^{WP,S}$	60			80			70			80			64			60		

As it is seen in table (3) unit 2, which as the lowest rate of pollution production according to its pollution generating curve, has participated in the whole time planning in power providing, with considering the pollutant emission. Also it can be seen in the table that in the 6th hour, wind power has been planned at its low level; because by adjusting the wind power at its predicted level, unit 2 is being planned for a lower power production.

As it is seen the generating pollution curve of the units, by decreasing the power production to 20 MW, pollutants emission of this unit will increase. So in low demand condition, in spite the fact that wind units are not pollution producers, high level of their production may lead to increase in produced pollution by each thermal unit. This fact shows the importance of considering the pollutants emission by thermal units in planning. It can be seen in table 4 that, also in multi – objective optimization with weighting method, the priority of power production is adjusted upon the offering cost of units. In these results, at the low demand hours unit 4 (the cheapest unit fro the point of view of power production) is the provider of the required power of the system. One of advantages of the weighting method is ability of adjusting the importance of objectives that is, the power system operator, regarding the importance of environmental issues. Can choose the amount of n which is effective in planning results.

Table 3- Results of Economical Planning of The System Operation With Considering The Generating Pollution Limit of Thermal Units

t	1			2			3			4			5			6		
generators	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	34	0	0	28	0	0	30	0	0	5	0	0	5	0	0	40	0	8
3	96	0	9	68	0	5	0	0	0	0	0	0	0	0	0	0	0	0
4	120	0	0	120	0	0	100	20	7	65	20	8	45	20	6	0	0	0
5	80	20	0	63	20	3	0	0	0	0	0	0	0	0	0	0	0	0
6	60	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$P_t^{WP,S}$	60			80			70			80			70			60		

Table 4- Results of System Operation Planning With the Goal of Simultaneous Decrease of Operation Cost and Generating Pollution with Weighting Method

t	1			2			3			4			5			6		
generators	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D	P_t^s	R_t^U	R_t^D
1	14	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	31	0	0	47	0	0	30	0	7	0	0	0	0	0	0	0	0	0
3	84	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	120	0	0	120	0	0	100	20	0	70	20	6	50	20	5	20	20	7
5	80	20	4	80	20	8	0	0	0	0	0	0	0	0	0	0	0	0
6	60	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$P_t^{WP,S}$	60			80			70			80			70			80		

IV. Conclusion

In this paper, a method for the commitment of units in presence of wind power production has been offered with considering the decrease in generating pollution of units. Also the units commitment scheduling is presented with the goal of covering the wind power uncertainty with stochastic security. This paper present two effective method for decreasing the units generating pollution. The first method is a multi-objective optimization method, with the goal of decreasing the operation cost and the pollutant gases emission produced by the units, simultaneously. Also another method is presented which can be used in a condition that limiting the air pollutant gases has the most priority. The suggested method has been tested on an IEEE 30- buses system and the results have been analyzed. The results of this test are representative of the effectiveness of the presented method.

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List of Symbols

C_{it}^{SU}	*Cost due to the scheduled start- up of unit i in period t [$]*
P_{it}^{S}	*Power out put scheduled for unit i in period t [MW]*
L_{jt}^{S}	*Power scheduled for load j in period t [MW]*
R_{it}^{U}	*Spinning reserve up scheduled for unit i in period*
R_{it}^{D}	*Spinning reserve down scheduled for load j in period t*
R_{it}^{NS}	*Nonspinning reserve scheduled for unit i in period t [MW]*
$P_{t}^{WP,S}$	*scheduled wind power in period t [MW]*
$P_{it\omega}^{G}$	*Power out put of unit i in period t and scenario ω [MW]*
$r_{it\omega}^{U}$	*Spinning reserve up deployed by unit i in period t and scenario ω [MW].*
$r_{it\omega}^{D}$	*Spinning reserve down deployed by unit i in period t and scenario ω [MW].*
$r_{it\omega}^{NS}$	*Nonspinning reserve deployed by unit i in period t and scenario ω [MW]*
$L_{jt\omega}^{shed}$	*Load shedding imposed on consumer j in period t and scenario ω [MW].*
$S_{t\omega}$	*Wind power generation spillage in period t and scenario ω [MW].*
$f_{t\omega}(n,r)$	*Power loss in line (n,r) in period t and scenario ω [MW].*
$\delta_{nt\omega}$	*Voltage angle at node n in period t and scenario ω [rad]*
P_{t}^{WP}	*Random variable modeling the wind power generation in period t [MW].*
λ_{t}^{WP}	*Marginal cost of the energy offer submitted by the wind producer in period t [$/ MWh].*
V_{jt}^{LOL}	*Value of load shed for consumer j in period t [$/ MWh]*
V_{t}^{S}	*Cost of wind power spillage in period t [$/ MWh]*

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