Procurement of Relevant Soil and Groundwater Quality – Quantity Standards

Subhashish Dey
Environmental Engineering Department, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India

***Abstract*- Environmental Impact Assessment (EIA) is an activity designed to identify and predict the impact of project on bio-geo-physico-chemical environment and on human health so as to recommend appropriate legislative measures, programmers and operational procedures to minimize the impact. EIA is an exercise to be carried out before any project or major activity is undertaken to ensure that it will not in any way harm the environment on a short-term or long-term basis. Any developmental activity requires not only the analysis, the monetary costs and benefits involved and of the need of such a project but also most important, it requires a consideration and detailed assessment of the effect of a proposed development on the environment. Often the results of manually-produced changes cause degradation in the surrounding environment. Although the proposed project or plan has a good intent and addresses an identified problem, or solves it, the ramifications of the project may be serious. For instance, it may result in degradation of the human environment offsetting the possible benefits of proposed project or plan. The aim of environmental impact assessment is to assess the overall impact of development project on the environment. An impact can be defined as any change in the physical, chemical, biological, cultural or socio-economic environmental system as a result of activities relating to the project.**
Keywords: Environmental Impact Assessment, Physico-chemical method, Development Activity and Socio-economic system.

I. INTRODUCTION

Land-use restrictions, soil quality standards, soil reclamation requirements and ground water quantity - quality standards, regulations, or policies are examples of institutional measures, which can be used to determine impact significance and required mitigation measures. Thus, to determine the specific requirements for a given project area will require contacting appropriate governmental agencies with jurisdiction. The primary sources of information needed for pertinent to the governmental agencies, namely, Central government, State government and/or local agencies. The prediction of impacts in a project activity on the soil and/or ground water environment(s), or conversely, the potential influence of environment(s) on a proposed project, can be approached from three perspectives qualitative, simple quantitative and specific quantitative. In general, efforts should be made to quantify the anticipated impacts; however, in many cases this will be impossible and reliance must be given to qualitative trend and through the spreading of excess sub-soil over the right way during clean-up. In general, the mixing of sub-soil with topsoil will have an adverse impact in soil fertility and soil structure [1-2]. The severity of impact will depend on the nature over sub-soil. A qualitative approach for groundwater - impact prediction involves the fundamental subsurface of environmental processes. The fundamental processes in the sub-surface environment can be examined relative to their hydrodynamic (physical), biotic (chemical), aspects. Several approaches can serve as a basis for interpreting the anticipated project induced changes in the soil and groundwater environments. One approach is to consider the percentage and direction of change from existing conditions for a particular soil or groundwater environmental factor. While this can be helpful it does presume that quantitative information is available for the baseline conditions for such factors, and that anticipated changes in the factors as a result of project can be quantified. Another approach for impact assessment is to apply the provisions pertinent to Central, State, or Local laws and regulations related to the soil and groundwater environment to be expected with project conditions. In many cases, these institutional requirements are qualitative; however, they can be used as ~ "yardstick" in evaluating the project and any features the project might incorporate to minimize environmental damage [3-4]. A third approach for interpreting anticipated changes relies upon professional judgment and knowledge. The anticipated changes could be interpreted in relation to existing Information on natural changes; next, the expected impacts could be placed in a historical context. A professional judgment based interpretation of anticipated changes may consist of applying rules of thumb. As an example, concerning soil erosion, the current and anticipated soil erosion patterns from a project area could be compared to regional averages or historical trends. It is generally agreed that a certain amount of soil loss is inevitable. Ideally, the loss should not exceed the rate of soil formation from parent rock and decomposed vegetation, but there is no agreement in the rate of soil formation. A commonly cited, generalized upper limit of permissible or tolerate soil loss is about 2ton/ha/yr, but the "permissibility" of such a loss depends on many local factors, such as, the fertility and drainage characteristics of the sub-soil. Many soils are vulnerable to a decline in productivity at a rate of loss from erosion considerably lower than II ton/h/lyr [5-6].

1.1 Environmental Analysis

After the above types of factors can be considered, the resultant conclusion may not be absolute. Subjective terms, such as the degree to which the project may induce development, may need to be used. The environmental analysis should yield the best possible prediction of environmental effects based on available information. The conclusions of analysis of potential induced development may be that the proposed project or action will- Definitely cause and promote increased density of land use, not cause any increase in development over what would occur in the future without the project, not necessarily cause increased development, but perhaps accelerate development slated to occur anyway, and not produce a development impact if local plans and policies stay unchanged, but indeed put into place the incentive for local planning bodies to change local comprehensive plans to permit higher-density land- use. Surface water bodies like rivers, streams, canals, ditches, ponds, reservoirs, lagoons, estuaries, coastal waters, lakes etc. which play very important role in the sustainability of any ecosystem and it is very important to assess the impacts of any developmental activity on these surface water environments. Impacts on surface waters in GIS base as shown in Fig. 1 are usually caused by physical disturbances (for example, the construction of banks, dams, dikes and other natural or manmade drainage systems), by changes in climatic conditions, and by the addition or removal of substances, heat, or microorganisms [7-8].

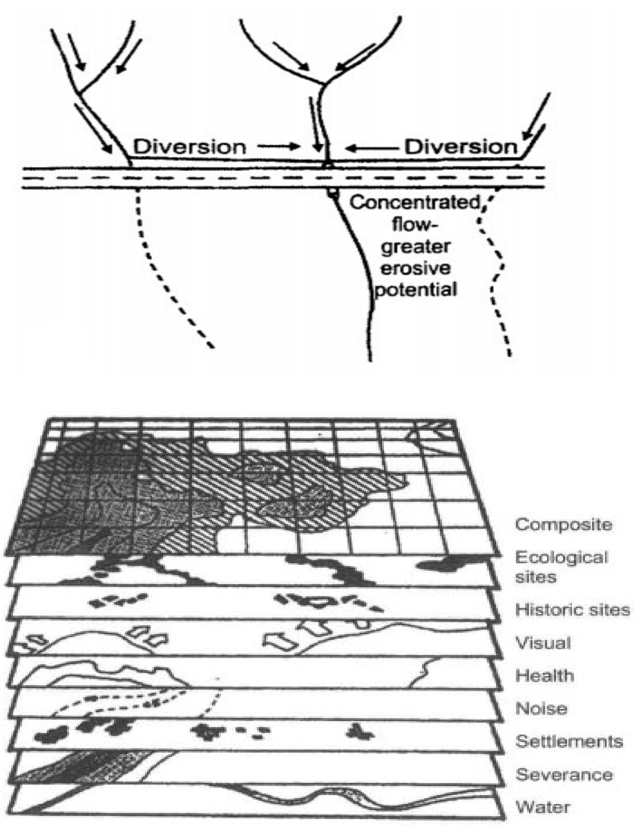


Figure 1: Concentrations of surface water flow modelling in GIS base

1.2 Soils and Groundwater

The integrity of soils and groundwater can be altered by a variety of physical disturbances, including the addition/removal of soil and/or water, compaction of soil. Changes in use of land or ground cover, changes in water hydrology, changes in climate (temperature, rainfall. wind) and the addition or removal of substances or heat (for example. discharge of effluents into groundwater, discharge of effluents or disposal of waste onto land, leaching of contaminants into groundwater, changes in quality of surface water and deposition of air pollutants on land). The effects of these vary from first order effects of leaching into soil and groundwater to changes in groundwater regime, soil structure (including erosion and subsidence), soil quality or temperature and groundwater quality or temperature [9-10].

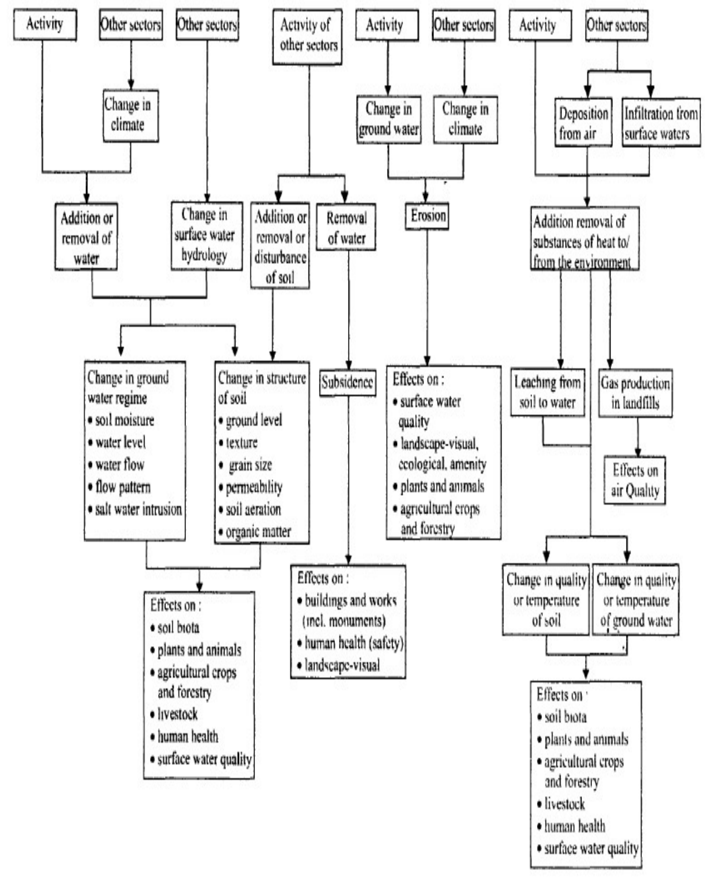


Figure 2: Analysis of soil and groundwater effects

To provide a basis for the addressing soil and/or groundwater environment impacts. A model was suggested, which connects seven activities or steps for planning and conducting impact studies. In Fig. 2 in analyzing environmental impacts, both objective and subjective judgments should be taken into consideration. Objective judgments are defined as those. Which involve or use the facts that are observable or veritable especially by scientific methods and which do not depend on personal reflections, feelings or prejudices "subjective” judgments are those which are made on the basis of values, feelings and beliefs ? In the context of environment objective judgment describes the impact where-as subjective judgment describes how people feel about the' fact' [11-13].

II. IDENTIFICATION OF SURFACE WATER QUANTITY OR QUALITY IMPACTS OF PROPOSED PROJECTS

The first activity is to determine the features of proposed project. The potential environmental output from project during its operational phase and information relatives to the water usage and water pollutant emissions, and waste-generation and disposal needs. The identified need for proposed project in the particular location (this need could be related to flood control, industrial development, economic development and many other requirements; it is important to begin to consider project need because it will be addressed as part of the subsequent related environmental documentation) [14-15]. Any alternatives which have been considered, with generic alternatives for factors including site location, project size, project design features and pollution control measures and project timing relative to construction and operational phases. The focus of this step is on identifying potential impacts of project. This early qualitative identification of anticipated impacts as shown in Fig. 3, help in refining subsequent steps. For example, it can aid in describing the affected environment and in calculating potential impacts. This is also including consideration of generic impacts related to the project type [16-17].

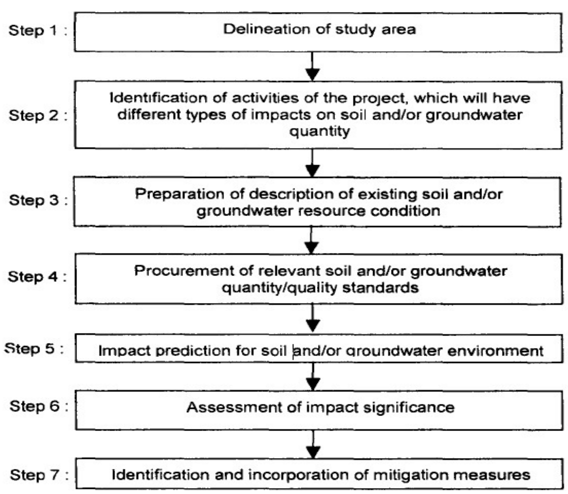
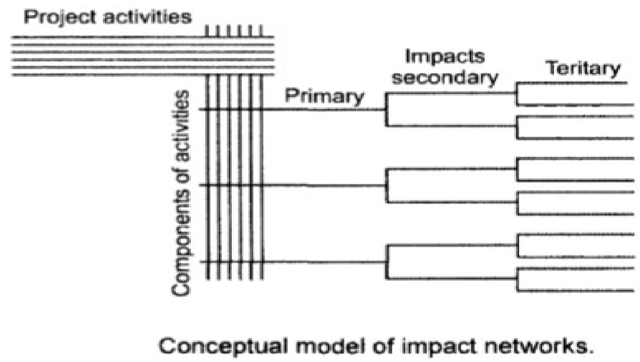


Figure 3: Systematic approach for the study of impacts on soil and ground water

III. GEOGRAPHIC INFORMATION SYSTEM FOR WATER QUALITY MEASUREMENT IMPACTS

GIS can show how a natural resource will be affected by a decision. Based on satellite data areas that suffer most from deforestation may be identified and analyzed on the basis of overlaying data on soil types, the species required, the likely growth and yield and impact of regulatory measures applicable to that area. The evaluation of various geospatial methods with reference to various assessment processes are presented in Fig. 4. The impact of various development plans on the environment can be assessed by integrating data on land use with topographic and geological information. Similarly satellite imagery can be periodically used to update maps of indicated land. The spectral features of irrigated and non-irrigated fields can be combined with other data on the fields to derive estimates of demands for irrigation water and devise land management plans [18-20].



Appropriate study period	Measure
Short-term	Physiological responses — heart rate, stress hormones Behavior and activity budgets Space and habitat-use
Long-term	Reproductive success and productivity Survival or mortality rates Abundance or density Distribution or occupancy rates Species richness Species diversity

Figure 4: Conceptual model of impact network on short term and long term basis

GIS can be used to assess the risk of drought in choosing areas for rain fed crops. GIS is a powerful management tool for resource managers and planners. Its applications are limited only by the quality, quantity and coverage of data that are fed into the system. Some of the standard GIS applications are integrating maps made at different scales. Overlaying different types of maps, which show different attributes and identifying, required areas within a given distance from roads or rivers, For example by overlaying maps of vegetation and soils a new map on land suitability can be generated and the impact of proposed projects can be studied. Similarly the most favourable zones for the development of shrimp farming outside mangroves can be located [21-22].

IV. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

IEE is a means of reviewing the environmental integrity of projects to help determine whether or not EIA level studies can be undertaken. In this sense IEE can be used for project screening to determine which projects require a full-scale EIA. IEE will have several other uses for ensuring project-oriented environmental management as well as minimizing the effort, expense, and delay in carrying out such planning.

IEE involves assessing the potential environmental effects of a proposed project that can be carried out within a very limited budget and will be based on the available recorded information or on the professional judgment of an expert. If the IEE results indicate that a full-scale EIA is not required, then any environmental management parameters. Such as, environmental protection measures or a monitoring programmed can be adapted to complete the EIA for such a project. If on the other hand, full-scale EIA is required, IEE can be of great help as a mechanism to determine and identify key issues that merit full analysis in EIA and to designate the issues that deserve only a cursory discussion. It may also identify other environmental review and consultation requirements so that necessary analyses or studies can be made concurrently with EIA. This would reduce delay and eliminate redundant discussion from EIA reports. IEE is a means of providing the most efficient and feasible preparation of adequate environmental management plans with or without the requirement of full scale EIA [23-25].

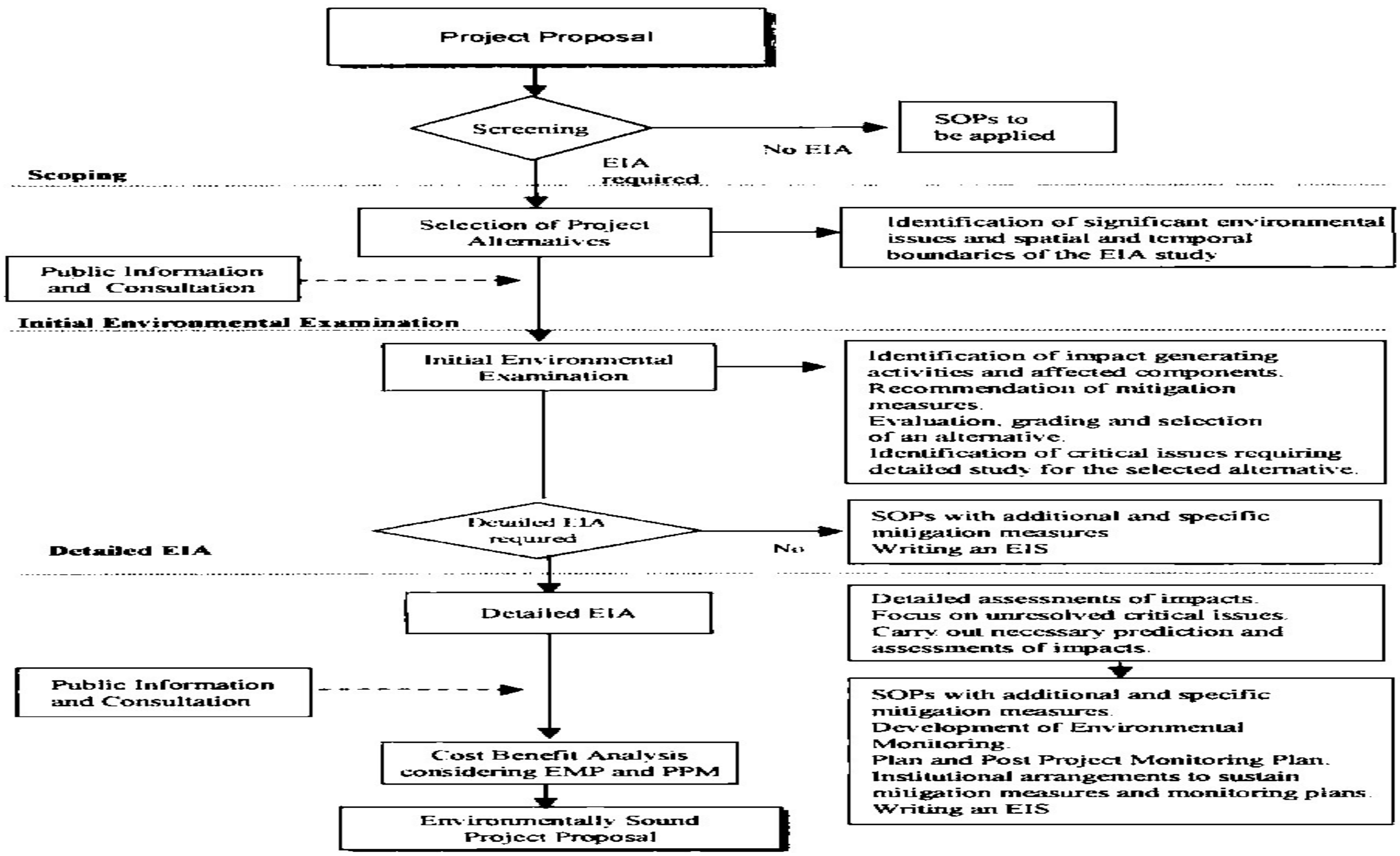


Fig. 5: Standard Operating Procedure for impact on soil and ground water

A multidisciplinary approach to environmental impact analysis is crucial to the decision making process and to an equal consideration for all areas of potential impact as shown in Fig. 5, when the tradeoffs of particular alternatives are evaluated. Therefore, the professional assessing impacts within a particular area of impact, such as, natural resources, air quality and neighbourhoods effects, must be educated and qualified within the disciplinary area. Impact assessment methods are classified into following analytical functions: Scope identification, prediction, and evaluation. Methods of identification of environmental impacts can assist in specifying the range of impacts that may occur, including their special dimensions and time frame. This usually involves the components of environment affected by the activities of project. The natural environment of man consists of air, water, land, noise, flora and fauna etc., while the man-made environment consists of socio-economic aspects, aesthetics, transportation etc [26-27]. Predictive methods will define the quantity or special dimensions of impact on an environmental resource. Methods of evaluation determine the groups (facility users or populations) that may be directly affected by the project or action. They will communicate to the decision maker what the deficiencies (tradeoffs) are between possible alternatives or courses of action and impacts associated with each alternative but the number of available tools and techniques for E.I.A, only a few look simple and suitable for developing countries [28-30].

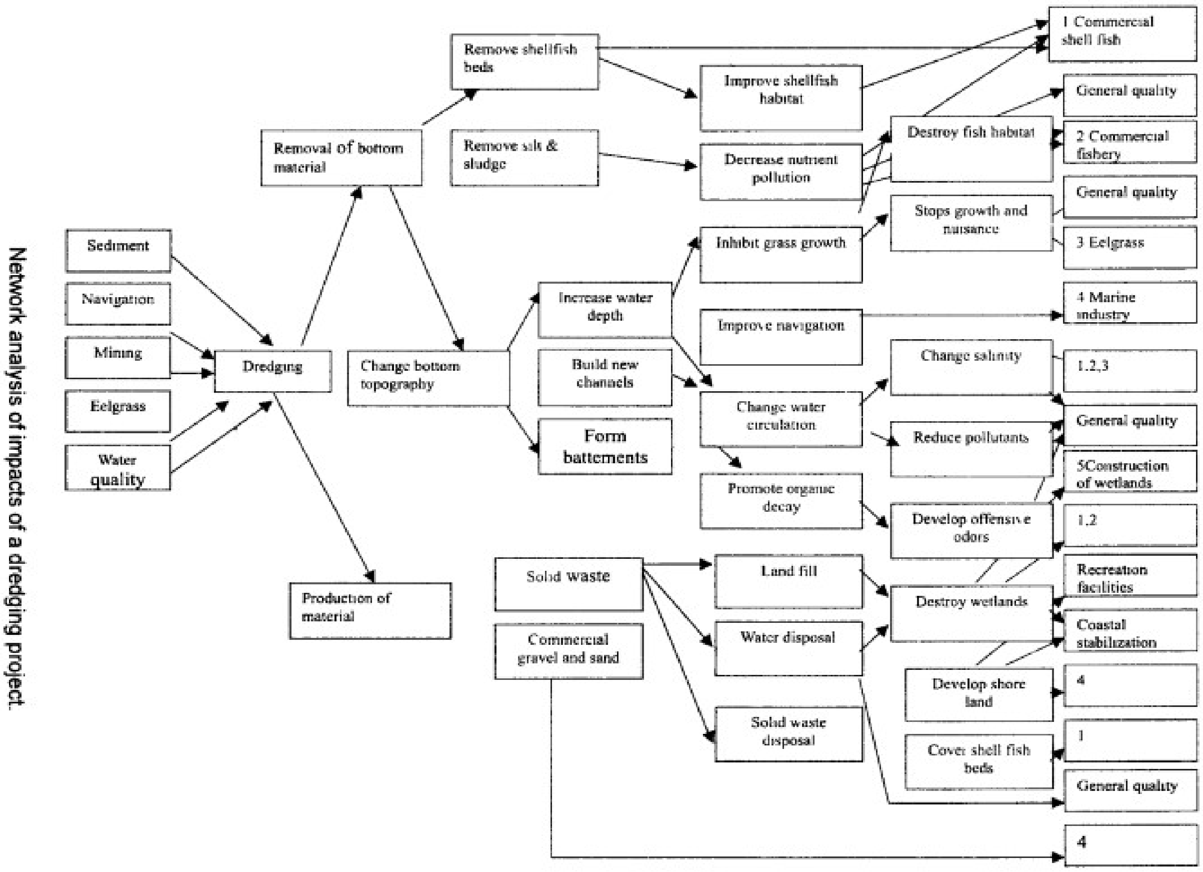


Figure 6: Networking Analysis of Environmental Impact Assessment

Monitoring studies that include an objective to assess changes in wildlife populations in response to changes in visitor activities will need to quantify human activities carefully. Sampling should be designed to capture the amount, types and intensity of human activity as well as how the activity varies spatially and temporally. Carefully measurement these elements will increase the ability to relate trends in the resource with changes in levels and types of human activity. There are number of tools for designing studies that can be used to increase the success of a monitoring program while balancing the interrelationships and trade-offs among sampling effort, cost and the overall ability of program to detect trends in resources [31-32]. In general, sampling designs that include elements to reduce sampling variability, such as shown in Fig. 6 stratified or cluster sampling, tend to be more efficient than those that do not account for heterogeneity of the response measure across the study area. Power analysis can guide some of the more challenging design questions, such as how many samples are necessary to meet study objectives, how large a trend is likely to be detected with a given amount of sampling effort, and what the probability of detecting a particular trend that is considered biologically meaningful might be. Monitoring changes in natural resources requires a detailed statement of goals and careful choice of parameters to be measured. To link monitoring to management, a threshold in the measure should be identified such that when the threshold was reached [33-34].

V. ENVIRONMENTAL AUDITING OF SOIL AND GROUND WATER

An environmental audit is a type of evaluation intended to identify environmental compliance and management system implementation gaps, along with related corrective actions. In this way they perform an analogous (similar) function to financial audits. There are generally two different types of environmental audits: compliance audits and management systems audits. these audits are intended to review the site's/company's legal compliance status in an operational context. Compliance audits generally begin with determining the applicable compliance requirements against which the operations will be assessed. This tends to include federal regulations, state regulations, permits and local ordinances/codes. In some cases, it may also include requirements within legal settlements. These audits may be multimedia or programmatic. Multimedia audits involve identifying and auditing all environmental media (air, water, waste, etc.) that apply to the operation/company. Programmatic audits (which may also be called thematic or media-specific) are limited in scope to pre-identified regulatory areas, such as air. Audits are also focused on operational aspects of a company/site, rather than the contamination status of the real property. ISO 14001 is voluntary international standard for environmental management systems ("EMS"). ISO 14001:2004 provides the requirements for an EMS and ISO 14004 gives general EMS guidelines. Checklist methodologies range from listings of environmental factors in highly structured approaches involving importance weightings for factors and application of scaling techniques for the impacts of each alternative on each factor. Impact identification is the most fundamental function of an EIA and in this respect, all types of checklists, namely simple, descriptive, scaling and weighting checklists do equally well [35-36].

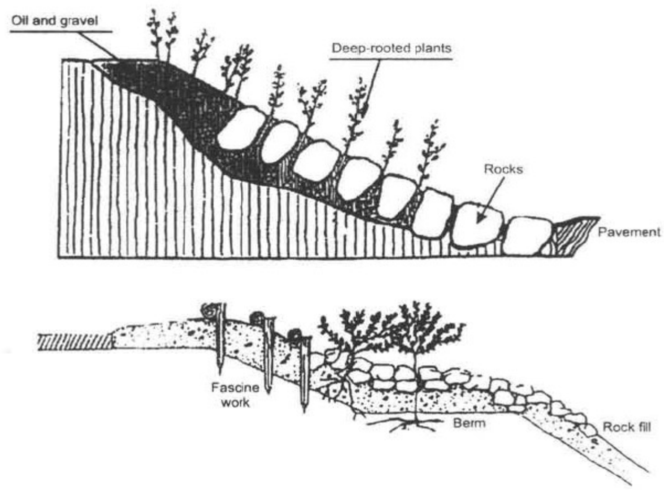


Figure 7: Flowing of ground water through the soil in various stages

Soil characteristics in a given geographical area at a point of time are a function of both natural influences and human activities. The soil and geological environments are typically associated with the physical and chemical environment. For example, the habitat types and associated vegetation found in an area will be a function of soil characteristics. Additionally, cultural resources may be related to soil characteristics or possibly as shown in Fig. 7, to unique geological features in an area. The relationship between shallow, alluvial aquifers and flow of surface streams and rivers may need to be explored. Table below summarizes the principal anthropogenic activities, which can cause ground- water pollution. In describing quantity and quality, specific indicator parameters can be utilized [37-38].

VI. ENVIRONMENTAL MONITORING AND AUDIT REQUIREMENTS OF SOIL AND GROUND WATER

With the implementation of proposed dust suppression measures, good site practices and dust monitoring and audit programmed, acceptable dust level would be expected at the ASRs during construction phase. Details of the monitoring requirements such as monitoring locations, frequency of baseline and impact monitoring was prepared in the form of EM&A manual as part of the EIA submission. With the implementation of mitigation measures through the design of the sewage treatment plant, air quality impact on the project is expected to be acceptable during the operational phase. Operational air monitoring is considered unnecessary. During the operational phase of project, all the potential odour generating facilities would be enclosed by the building structure [39-40]. The deodorization facility is designed to be able to achieve an odour removal efficiency of 99.5% for the exhaust of sewage treatment plant. During sludge transportation, it is recommended that the sludge should be carried in enclosed containers to avoid unacceptable odour nuisance. Membrane and filter in the STP should be regularly cleaned and replace to maintain the efficiency of sewage treatment and odour removal. With proper mitigation measures incorporated into the design, odour impacts arising from the proposed sewage treatment plant will be significantly reduced, and are anticipated to be acceptable. Many geographical areas exhibit special or unique problems that should be addressed in the description of baseline conditions for the soil or groundwater resources in the study area. Dry land farming practices involving irrigation often lead to salt accumulation in surface soils and shallow unconfined aquifers [41-42].

6.1 Procurement of relevant soil and groundwater quantity – quantity standards

Land-use restrictions, soil quality standards, soil reclamation requirements and groundwater quantity - quality standards, regulations or policies are examples of institutional measures, which can be used to determine impact significance and required mitigation measures. Thus, to determine the specific requirements for a given project area will require contacting appropriate governmental agencies with jurisdiction. In general, efforts should be made to quantify the anticipated impacts; however, in many cases this will be impossible and reliance must be given to qualitative trend and through the spreading of excess sub-soil over the right - of - way during clean-up. In general, the mixing of sub-soil with topsoil will have an adverse impact in soil fertility and soil structure. The severity of impact will depends on the nature of sub-soil. A qualitative approach for groundwater impact prediction involves the fundamental subsurface environmental processes. Another approach for addressing impacts on the soil environment is to use simple quantitative techniques, with a range of such techniques having been developed. One example of simple quantitative technique is the use of "overlay mapping"' which has been developed to delineate various land-use compatibilities in given geographical areas. Overlay mapping consists of utilizing a base map of the project study area and different soil or geological features of particular impact concerns of the proposed project. Impact prediction involves identifying where overlaps of particular concerns occur. Overlay mapping can be achieved through the development of hand drawn maps or the usage of computer-generated maps [43-44].

GIS is a database, which may contain multiple "layers" of data for the same area. Examples of possible layers are topographic data and adorability indices are shown. All layers are referenced to common ground - datum point and orientation, allowing them to be, in essence, overlaid. Data can be input to DIS by either analytical or digital means. The viability of population depends on the presence of suitable environment with adequate resources. All organisms are constantly affected by and interact with a complex of environmental factors including aboitic (physic-chemical factors like water, temperature light, oxygen nutrients toxins pH etc) and biotic factors (which involve interactions between species i.e., competition, predation, parasitism and mutualism. Species can tolerate nominal short term environmental variations while populations undergo marked temporary fluctuations, they tend to remain stable in long term. Species also may be capable of responding to slow progressive environmental changes by evolving or changing their geographical range. However their adaptations have evolved in response to slow past environmental conditions and may be unable to adjust quickly enough to rapid environmental changes. One of the greatest threats to most species is habitat loss together with associated habitat fragmentation due to urbanization. The key issue which causes irreversible population loss is the ability of species populations to survive in and move between small isolated habitat patches scattered within an urban or agricultural matrix [45-46].

VII. CONCLUSIONS

One of the most important contributions of an initial overview assessment is the early input of environmental considerations for the design or development of the project, action, or plan. If coordination is efficient among the various members of team for the project or action, the information provided by an initial overview can lead to better projects with fewer environmental impacts. These "least environmentally damaging" alternatives are then the ones evaluated in the subsequent detailed environmental studies and public and agency review process. The development and analysis of alternatives form is very core of environmental impact assessment which is nothing but comparative analysis of alternatives. Environmental impact statements are often titled Draft (or Final) environmental impact assessment alternatives analysis. The driving impetus for conducting environmental impact studies is to make comparative study of the effects of proposed alternatives so as able to arrived a better decision-making because of its importance in the impact analysis; the study of alternatives should be a thorough and systematic process. It should include input from Central and State governments, local agencies and general public. Decisions made at every phase of analysis should be logical and documented on the basis of solid plat form of evaluation criteria. The alternatives section of Environmental Assessment/ Finding of no significant impact or the draft and final environmental impact statements is the most noteworthy portion of the environmental document. Environmental legislation is the collection of laws and regulations pertaining to air quality, water quality, the wilderness, endangered wildlife and other environmental factors. GIS is beginning to be used in impact studies, since it can be valuable tool for assessing cumulative impacts. GIS can also be used to quantify rates of regional resource loss by comparing data layers representing different years. In addition, GIS can be used to develop empirical relationships between resource loss and environmental degradation.

REFERENCES

[1] Air quality criteria for carbon monoxide. Washington, DC. US Environmental Protection Agency, Office of Research and Development, (publication no. EPA-600/B-90/045F) (1991).
[2] Amin, C.M., Rathod, P.P., Goswami, J.J. International Journal of Engineering Research & Technology 1, 1-6, (2012).
[3] Automobile and carbon monoxide, U.S. Environmental protection agency office mobile sources. EPA400-F-92-005.
[4] Badr, O., Probert, S.D. Applied Energy 49, 99-143 (1994).
[5] Chen, H., Tong, X., Li, Y. Applied Catalysis A: General 370, 59-65 (2009).
[6] Chhatwal, G.R., Mehra, M.C., Sataka, M., Katyal, T., Katyal, M., Nagahiro, T. In environmental air pollution and its control. Anmol Publications, New Delhi (1975).
[7] Cholakov, G.S. Pollution Control Technologies 3, 1-8 (2010).
[8] Clarke, T.J., Davies, T.E., Kondrat, S.A., Taylor, S.H. Applied catalysis B: Environmental 165, 222-231 (2015).
[9] Liu, Q., Liu, C., Nie, X., Bai, L., Wen, S. Materials Letters 72, 101-103 (2012).
[10] Cole, K.J., Carley, A.F., Crudace, M.J., Clarke, M., Taylor, S.H., Hutchings, G.J. Catalysis Letters 138, 143-147 (2010).
[11] Fortunato, G., Oswald, H.R., Reller, A. Journal of Material Chemistry 11, 905-911 (2000).
[12] Fuzhen, Z., Miao, G., Guangying, Z., Jinlin, L. Journal of Rare Earths 330, 604-610 (2015).
[13] Ghaffari, A., Shamekhi, A.H., Saki, A., Kamrani, E. World Academy of Science, Engineering and Technology 48, 284-292 (2008).
[14] Goldsmith, J.R., Aronow, W.S. Journal of Environmental Research 10, 236-248 (1975).
[15] Guo, X., Li, J., Zhou, R. Journal of Fuel 20, 56-64 (2016).
[16] Hasegawa, Y., Maki, R., Sano, M., Miyake, T. Applied Catalysis A: General 371, 67–72 (2009).
[17] Thormahlen, P., Skoglundh, M., Fridell, E., Andersson, B. Journal of Catalysis 188, 300-310 (1999).
[18] Hasunuma, H., Ishimaru, Y., Yoda, Y., Shima, M. Environmental Research 131, 111-118 (2014).
[19] Hoshyar, N., Irankhak, A., Jafari, M. Iranian Journal of Chemical Engineering 12, 3-14 (2015).
[20] Hutchings, G.J., Mirzaei, A.A., Joyner, R.W., Siddiqui, M.R.H., Taylor, S.H. Catalysis Letters 42, 21-24 (1996).
[21] Hutchings, G.J., Mirzaei, A.A., Joynerb, R.W., Siddiqui, M.R.H., Taylor, S.H. Applied Catalysis A: General 166, 143-152 (1998).
[22] Ismaila, S.O., Bolaji, B.O., Adetunji, O.R., Adekunle, N.O., Yusuf, T.A., Sanusi, H.O. International Journal of Engineering 1584, 178-180 (2013).
[23] Jones, C., Cole, K.J., Taylor, S.H., Crudace, M.J., Hutchings, G.J. Journal of Molecular Catalysis A: Chemical 305, 121–124 (2009).
[24] Jones, C., Taylor, S.H., Burrows, A., Crudace, M.J., Kielyb, C.J., Hutchings, G.J. Chem. Commun 1707, 1 (2008).
[25] Sharaf, J. International Journal of Engineering Research and Applications 3, 947-960 (2013).
[26] Kondrat, S.A., Davies, T.E., Zu, Z., Boldrin, P., Bartley, J.K., Carley, A.F., Taylor, S.H., Rosseinsky, M.J., Hutchings, G.J. Journal of Catalysis 281,279–289 (2011).
[27] Larsson, P., Andersson, A. Applied Catalysis B: Environmental 24, 175–192 (2000).
[28] Ivanov, K.I., Kolentsova, E.N., Dimitrov, D.Y., Avdeev, G.Y., Tabakova, T.T. International Scholarly and Scientific Research & Innovation 9(6), 719-724 (2015).

[29] Santra, A.K., Goodman, D.W. Electrochimica Acta 47, 3595-3609 (2002).
[30] Solsona, B., Hutchings, G.J., Garcia, T., Taylor, S.H. New Journal of Chemistry 28, 708–711 (2004).
[31] Lee, J., Kim, H., Lee, H., Jang, S., Chang, J. H. Nanoscale Research Letters 11, 2-6 (2016).
[32] Favez, J., Weilenmann, M., Stilli, J. Atmospheric Environments 43, 996–1007 (2009).
[33] Jackson, N.B., Datye, A.K., Mansker, L., O'Brien, R.J., Davis, B.H. Studies in Surface Science and Catalysis. 111, 501-509 (1997).
[34] Rostrup-Nielsen, J.R. Promotion by poisoning. Studies in Surface Science and Catalysis. 68, 85-101 (1991).
[35] Barbier, J. Effect of poisons on the activity and selectivity of metallic catalysts. In deactivation and poisoning of catalysts; Marcel Dekker: New York, NY, USA, 109–150 (1985).
[36] Hu, Y., Dong, L., Wang, J., Ding, W., Chen, Y. Journal of Molecular Catalysis A: Chemical 162, 307–316 (2000).
[37] Kam, E.K.T., Hughes, R. Chemical Engineering Journal 18, 93-102 (2001).
[38] Dvorak, R., Chlapek, P., Jecha, D., Puchyr, R., Stehlik, P. Journal of Cleaner Production 18, 881–888 (2010).
[39] Houshmand, D., Roozbehani, B., Badakhshan, A. International Journal of Science Emerging Technology 5, 234-238 (2013).
[40] Nisar J., Ali, M., Awan, I.A. Journal of the Chilean Chemical Society. 56, 653-654 (2011).
[41] Morales, M.R., Barbero, B.P., Cadus, L.E. Applied Catalysis B: Environmental 67, 229–236 (2006).
[42] Haruta, M., Yamada, N., Kobayashi, T., Lijiama, S. Journal of Catalysis 115, 301-309 (1989).
[43] CONCAWE, Environmental science for the European refining industry. https://www.concawe.eu/ (1992).
[44] Pulkrabek W.W. Engineering fundamentals of the internal combustion engine. Pearson Prentice Hall, New Jersey (2004).
[45] India Bharat Stage VI emission standards, Policy Update, International Council of Clean Transportation (2016).
[46] EPA, Air Act, US. Summary of the Clean Air Act. Www.epa.gov. Retrieved 2015-12-22.