Engineering News

A Quarterly Journal of the Pakistan Engineering Congress

Vol: 42 January - June 2006 No: 8 & 9







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COVER PHOTOGRAPHS

Top : Massive cliff failure (Muzaffarabad)

Bottom Left : Balakot Bridge of National Route #15 : The entire deck moved about 1m downstream side.

Bottom Right : Suspension Bridge near Balakot Bridge : The right tower was cut off and shifted towards downstream side.

47th YEAR OF PUBLICATION

Engineering News

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PUBLISHED BY
Pakistan Engineering Congress
Ph: 5784237-5784238 Fax: 5784236

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Editorial

What is going on within the Engineering Organizations ?

First anniversary of Oct 8, 2005 earthquake has approached with mixed feelings. Sorrowful feelings of mass destruction of vast area of Pakistan causing huge loss of life and property and feelings of pride and satisfaction arising out of equally huge response from government, NGOS and public Atleast for some time the nation felt shocked but united for good cause of saving lives and assisting injured under adverse conditions. Lack of adequate preparation, however, remains the national concern. Although with zeal and devotion many hearts were won, the process of healing the wounds is on.

Soon after the disaster the Govt. of Pakistan established the much needed Authority which has done a great deal to provide financial assistance for victim families subsistence and repair to their lost and damaged shelters. Houses of more permanent nature, schools, mosques, hospitals and other infrastructure is being provided. However, measures to mitigate the impact of future catastrophes is not greatly visible. Disaster control agency is the need of the day which besides optimizing the use of government machinery and resources, must instill sense of readiness in the minds and hearts of public, non-governmental set-ups and other private organizations. The Agency must operate on war footings and as soon as such type of calamity befalls it starts assisting and protecting the victims. In the earlier days there used to be an organization called civil defence which could provide some assistance and help during war and floods but presently it seems non-existent or dormant at its best. Most of the damage during the earthquakes was from crumbling buildings which were built without following building standards and codes and without exercising proper supervision. Building control departments have miserably failed to guide public and assist government to achieve even minimum of safety standards for normal situations what to speak of quake of 7.6 RS intensity. Even now we do not know the direction we are moving to. Pakistan Engineering Congress and council should be pushing the Government and concerned organizations to promptly prepare and promulgate standards for investigation, design, planning and construction of buildings. Quality of materials and construction must have safety factor for earthquakes, wind storms, flooding and tsunami impact.

A lot is expected from engineering organizations, consulting firms and universities. There is hardly any research conducted by the universities, if there is any, it is not published and there is no visible activity on exchange of data, information and views amongst the nation-buildings departments. Falling plazas, ailing buildings and broken roads do not speak high of them. In fact there is a negative tendency to keep the data to their hearts. No case studies, project defects and failures are published. No project defects and failures are high-lighted even within the engineering circles. Project planning cycle of surveying, planning, designing, approval of projects, construction operation and maintenance and final evaluation of project impact is attended only to half way depriving us all of lessons to be taken from the success or failure. In this respect annual reports must be prepared at all levels to assure the users, consumers and public at large that, tax money and user charges are not going to drain and instead are well spent and benefited by public will.

Last but not the least, the Engineering News Journal is running out of quality papers for publishing and even the quantity is inadequate to select from. This needs special attention of managers and administrators of engineering organizations, particularly the Deans and vice-chancellors of engineering universities and heads of engineering departments for gearing their institutions for research and development, publish and disseminate their work for best national interest.

WELCOME TO NEW MEMBERS

The Executive Council of the Pakistan Engineering Congress approved Membership of the following new members in to the Congress fold. The Engineering News congratulates all of them and welcomes them to PEC.

Members admitted on 28-01-2006

1 Engr. Muhammad Shahzad
2 Engr. Imran Yousaf Rana
3 Engr. Jamsheed Naseer Khan
4 Engr. Muhammad Akmal
5 Engr. Aqeel Bin Shoukat
6 Engr. Ammad Hassan Khan
7 Engr. Fazal Karim
8 Engr. Ghazanfar Abbas
9 Engr. Muhammad Tahir
10 Engr. Muhammad Altaf
11 Engr. Rana Sharjeel Ayaz

Members admitted on 18-03-2006

1 Engr. Muhammad Umar Manzoor
2 Engr. Muhammad Adeel Mazhar
3 Engr. M. Khurram Jehanzeb
4 Engr. Altaf Hussain
5 Engr. Muzammil Hashmat
6 Engr. Tanveer Ahmad Fayyaz
7 Engr. M. Rafique Sulehria
8 Engr. Maj. (R) S. Mashhadi Hussain Zaidi
9 Engr. Syed Hammad Mashhadi
10 Engr. Ali Arshad Hakeem
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15 Engr. Shahid Mahmood
16 Engr. Abrar Hussain Khan
17 Engr. Shujja Naveed
18 Engr. Maj. (R) Muhammad Farooq
19 Engr. Fayaz Hussain Shah
20 Engr. Hazoor Bakhsh
21 Engr. Salim Khan
22 Engr. Pervez Khan
23 Engr. Muhammad Sabir Shah
24 Engr. Irfan Majeed
25 Engr. Khalid Mahmood
26 Engr. Atiq-ur-Rehman
27 Engr. Muhammad Atiq-ur-Rehman
28 Engr. Ch. Muhammad Nawaz
29 Engr. Muhammad Aamir
30 Engr. Muhammad Aftab Azhar
31 Engr. Shahid Zaheer
32 Engr. Riaz-ud-Din
33 Engr. Mehmood Alam
34 Engr. Shahid Sattar Khan
35 Engr. Muhammad Tufail Cheema
36 Engr. Ata-ul-Haque Akhtar
37 Engr. Rauf Akbar Mustafa
38 Engr. Syed Shahjehan
39 Engr. Arif Muhammad Qazi
40 Engr. Syed Abdul Wahab
41 Engr. Subhash Chander
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48 Engr. Qaiser Abbas
49 Engr. Rafaqat Iqbal
50 Engr. Khalid Qureshi
51 Engr. Muhammad Asghar
52 Engr. Faiz Ahmed Faiz
53 Engr. Muhammad Qanateer Ahmad
54 Engr. Tariq Hamid Butt
55 Engr. Muhammad Iqbal
56 Engr. Rehan Afzal Malik
57 Engr. Altaf Khan
58 Engr. Shahid Iqbal
59 Engr. Maj. (R) Muhammad Mansoor
60 Engr. Muhammad Uzair Khan
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67 Engr. Muhammad Saleem Khan
68 Engr. Zarin Gul
69 Engr. Malik Asad Yar Khan
70 Engr. Waseem Anwar
71 Engr. Brig. Nasrullah Abeer
72 Engr. Nawazish Ali
73 Engr. Jamil Ahmad

Members admitted on 08-04-2006

1 Engr. Zia-ul-Hassan Khan
2 Engr. Muhammad Atif-ur-Rehman
3 Engr. Danish Rafique
4 Engr. Luqman Zaffar
5 Engr. Muhammad Shafqat Khalid
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9 Engr. Hafiz Muhammad Ramzan
10 Engr. Intizar Ali
11 Engr. Irfan Ullah
12 Engr. Roshan Ali Bhatti
13 Engr. Khurshid Ahmed Mirza
14 Engr. Naveed Abbas

Members admitted on 20-05-2006

1 Engr. Muhammad Usman Rashid
2 Engr. Muhammad Shahzad
3 Engr. Shafiq Ahmad
4 Engr. Asif Hayat Bhatti
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6 Engr. Muhammad Tayyab Ahmad
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10 Engr. Ali Javaid Ghuman
11 Engr. Najamuddin Shaikh



MANAGING DIRECTOR NESPAK ELECTED EXECUTIVE COMMITTEE MEMBER OF FIDIC-ASPAC

Mr. Karamat Ullah Chaudhry, Managing Director of NESPAK has been elected as an Executive Committee Member of International Federation of Consulting Engineers for Asia Pacific Region (FIDIC-ASPAC) at an Annual Conference held in Budapest (Hungry). FIDIC is an international body of 74 member countries.

According to an e-mail message received here today, Mr. Chaudhry has been elected to the world body of Consulting Engineers for a 3 years term (2006-2009), which is indeed an honour for Consulting Engineers of Pakistan.

Mr. Chaudhry is the current President of Association of Consulting Engineers Pakistan (ACEP) and first President of ACEP who has been elected to the august body of FIDIC-ASPAC Executive Committee.

10th International Symposium on
ADVANCED MATERIALS
3-7 September 2007, Islamabad, Pakistan

The 10th International Symposium on Advanced Materials (ISAM-2007) will be held in Islamabad, Pakistan, from 3-7 September 2007. The First International Symposium on Advanced Materials was held in 1989. This biennial event has become a prime international forum where materials engineers and scientists keep abreast with latest developments in the field of advanced structural and functional materials. The forum promotes global exchange of information and expertise amongst the participants. One of the aspects of the Symposium is close collaboration between scientists, engineers and industrialists thus providing an opportunity to create links for future developments.

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OBITUARY

May their souls rest in Peace

1. Engr. Ch. Muhammad Iqbal (R) Chief Engineer Irrigation

2. Engr. Abdul Basit Akhtar

3. Engr. Ahmed Hussain Qureshi, Former Vice-Chancellor, University of Engineering and Technology Lahore (Passed away on 7th March 2006)

4. Engr. Dr. Khalifa Saeed-ud-Din, Former Director / CEO of NFC Institute of Engineering and Technology Multan (Passed away on 22nd March 2006)

5. Engr. Dr. Lt. Gen Ghulam Safdar Butt a Veteran Engineer and Former Chairman WAPDA passed away on May 10, 2006. He was born on March 13, 1928. He graduated in the discipline of Civil Engineering from Military College of Engineering Peshawar University in 1950 and Master of Civil Engineering from IOWA State University (USA) in 1965 and Doctor of Engineering from the same University in 1967. He had a distinguished carrier and was member of numerous International and National Professional bodies. The following awards were conferred on him in recognition of his meritorious and outstanding services.

(i) Outstanding contribution to Engineering and Research awarded by George Washington University, Washington D. C. in 1985.

(ii) S. Bt "Star of Val our" awarded by Government of Pakistan in 1985.

(iii) Outstanding Achievements Award by Iowa State University, Ames, Iowa, USA in 1981.

(iv) HIM "Moon of Distinction" awarded by Pakistan Government, 1979

He was Member / Fellow of prestigious National and International Professional bodies.

His demise was widely mourned by individuals and Institutions.

6. Engr. Ali Abbas Asghar Nami of Republic Engineering Corporation Lahore (Passed away on 24 May 2006)

7. Engr. Iftikhar-ud-Din Afghani died on 29 June, 2006. He had been a prominent engineer working with ACE a well known Consulting Firm of Pakistan. He was born on 14th September 1937, graduated from Maclagen College later University of Engineering and Technology, Lahore and worked at various projects in WAPDA until 1977. Later on he worked in Nigeria and Indonesia (representing ACE) and had a long innings with Indus Consultants where he helped in lining the Lahore Canal as well.

8. Engr. Lt. General (R) Jehangir Nasrullah Former Engineer in-chief Pak Army.

9. Engr. Sheikh Maqsud Ali Former Ex-General Manager WAPDA. (Passed away on 8-7-2006). Also see page 7 & 8.

OBITUARY

In Memoriam

SHEIKH MAQSUD ALI

Ex-General Manager WAPDA



Engr. Sheikh Maqsud Ali, born on 23 March 1931 breathed his last on July 08, 2006. He was a Civil Engineer from the N. E. D. Engineering College at Karachi. He joined Warsak Dam Project in 1957-1958 where he supervised civil works. After completion of this Project, he joined WAPDA in 1960 and during his long and meritorious career, he contributed substantially to the following Mega Projects :

(i) He supervised construction of civil works at Mailsi-syphon Barrage. As Executive Engineer he was responsible for all development works at the Barrage site.

(ii) As Deputy Project Director at Mangla Dam Project he managed all contracts pertaining to civil works of the Project.

(iii) During 1971, he was posted to Tarbela Dam Project and remained associated with all phases of construction till final commissioning of the Project. His work was highly appreciated and he was recognized by WAPDA, the Consultants and the Contractors as a person whose dedication to his Organization, Society and the Country was exemplary.

(iv) He worked as General Manager (Dams and Coordination) WAPDA and was responsible for operation of all Dams and Barrages of Pakistan either built under the Indus Waters Treaty or otherwise. He was in fact regarded as an institution in the development and maintenance of Water Sector Projects.

(v) He drafted and standardized the International and National Contract Documents. His efforts were highly appreciated by the World Bank.

(vi) He also worked as Member on the Panel of Experts of the Asian Development Bank and contributed on numerous issues from his technical and practical wisdom.

Due to his contribution to various projects during service in WAPDA, he was awarded the following medals / awards :

(a) Special Medal on Inauguration of Warsak Dam Project.

(b) Gold Medal on Inauguration of Indus Basin Project.

(c) WAPDA's Meritorious Shield and First Prize.

After his retirement from WAPDA in 1991, he was appointed as Principal Advisor (Projects) and Managing Director (Pakistan WAPDA Foundation).

He was also Managing Partner, Review Consultants. Most recently he was involved in the assessment of claims on Ghazi Barotha Hydropower Project, leading to the resolution of disputes between the Contractor, the Government of Pakistan and WAPDA.

As a human being he was considered to be the most human, down to earth, God fearing, helpful, affectionate and loving person. He was beacon of knowledge for his peers, colleagues, juniors and family members. His words were source of inspiration, strength and full of wisdom. He had an outstanding ability to understand, analyze, rectify any situation, professional or in his private life. He supported various charitable organizations and efforts made in this direction.

As President, TECH Society, Lahore for four and a half years (two terms) he initiated various community welfare projects and successfully completed them thus making the Society a place worth living having all civic amenities.

He has left behind his loving affectionate and caring wife who has always been a source of inspiration and support for him in his most illustrious career and most satisfying life. His two sons, Sheikh Shahid Maqsud and Sheikh Zahid Maqsud, their wives and four grand children were all besides him when he breathed his last on 8th July 2006. We pray that his soul may rest in peace and Pakistan should have more sons like him who till his loss, wanted to work more for the prosperity of his beloved Country as desired by the Father of the Nation.

DISINFECTION TECHNIQUES OF RURAL WATER SUPPLIES IN DEVELOPING COUNTRIES

By

Husnain Haider*

ABSTRACT

About 1.2 billion people in the world have none or lack access to safe drinking water and most of them are living in developing countries. This paper reviews briefly different disinfection techniques in the developing countries context both at the household level and for community water supplies in rural areas, including filtration, boiling, solar water disinfection (SODIS), chlorination, ultraviolet radiations (UV) and mixed oxidant gases. Comparison between different disinfection technologies is also carried out to come up with the most cost effective and easy to use solution of disinfection. For surface waters, multistage filtration supported with disinfection through chlorination for rural water supplies appears to be the most feasible option. However, difficulties associated with lack of skilled manpower to control chlorine doses can be omitted by disinfecting filtered waters at household level through SODIS or boiling rather than chlorination at the plant site. SODIS experience in developing countries so far has shown that it is another appropriate technology if disseminated through government and media support. For rural water supplies, there still a need exists to develop more reliable and simple methods of disinfection.
Key Words: Disinfection, Chlorination, Solar Water Disinfection, Water Quality, Filtration, Ultraviolet Radiations, Rural Water Supply

1) INTRODUCTION

The World Health Organization (WHO) estimates that 1.2 billion people are affected by polluted water worldwide. Furthermore, about 400 children below the age of five die per hour in the developing world from waterborne diarrheal diseases (WHO 1996) [Ref. 39]. It is estimated that 80% of all sicknesses and diseases in developing countries are caused by unsafe water. The single most important requirement of drinking water is that it should be free from any microorganisms that could transmit disease or illness to the consumer such as typhoid fever, dysentery, cholera, and gastroenteritis. Such microorganisms include: protozoa, bacteria, virus and many of these are deposited into a water source because of fecal contamination from humans, livestock and wild animals. In addition, worms are a large problem in many developing countries that have surface water sources used for water gathering for domestic uses and bathing in close proximity to areas used by animals.

Each stage of water treatment process such as storage, sedimentation, coagulation and flocculation, and filtration reduces, to varying degrees, the bacterial content of water. However, to be absolutely sure that waterborne disease organisms are eliminated, disinfection of all water supplies is necessary. This is aimed both at inactivating bacteria before distribution and providing residual disinfectant to inactivate bacteria produced by any subsequent ingress of contaminated water during storage or distribution.

Lack of financial resources and skilled labour to develop and operate elaborate drinking water infrastructure, favored in the developed world, demand simple solution. Therefore, there is an urgent need for introducing treatment options that can be owned, operated and managed at the community or even at household levels in developing countries.

* Assistant Professor, Institute of Environmental Engineering & Research, UET, Lahore

The paper reviews different disinfection technologies currently being used in rural areas of developing countries. Pretreatment methods to remove high suspended solids and improve microbiological quality of water to ensure effective disinfection are also being outlined. The paper also presents a comparison between different disinfection technologies for rural areas in developing countries.

2) METHODS OF DISINFECTION IN DEVELOPING COUNTRIES

Disinfection is a process in which disease producing organisms are destroyed. This process may be accomplished by a number of different physiochemical treatment methods, which can be broadly divided into following two groups.

A. Physical methods: boiling water, ultraviolet radiation, Solar Water Disinfection (SODIS), and filtration.
B. Chemical methods: chlorine gas and chlorine solution (hypochlorite), ozone gas, mixed oxidant gases generated on demand (MOGGOD), potassium permanganate, iodine, bromine and metallic ions such as copper and silver.

A good disinfectant should be quick acting; readily soluble; free from taste, colour and odour; non-toxic; easy to detect and measure and readily available at moderate cost. Ozone is not suited for most developing country applications owing to its high cost, need for operational and maintenance infrastructure, and lack of residual protection in the distribution system and therefore is not covered in this paper. Significant health related effects of iodine, staining behavior of potassium permanganate and need of very long contact time for silver make them unsuitable almost in all cases. Boiling is a simple technique that can be used in emergency cases but not suitable for the regions having none or lack access to burning fuels or gases.

Chlorine was introduced as a disinfectant of water supplies in the United States (US) in 1908. It is reliable and effective against a wide spectrum of pathogenic organisms, moreover, effective in oxidizing certain organic and inorganic compounds. The residual disinfection effect of chlorine is a useful property which ensures disinfection right up to the tap, and is very important for developing countries having old and poorly managed water supply networks.

SODIS is a simple, environmentally sustainable, low-cost solution at household level, especially for rural and remote areas. Most commonly used disinfection technologies are briefly reviewed in the following sections of the paper.

2.1 Filtration

Slow sand filters (SSFs) are more effective than rapid filters for developing countries at removing particulates and microbial contaminants and are also simpler to operate. A layer of active biological community known as schmutzdecke develops in the sand up to a few centimeters below the top surface and captures organic particulates and microbial contaminants in the inlet water. SSFs permit large reductions in bacterial and viral contamination and remove larger biological contaminants such as cryptosporidium, giardia, amoebae and parasite eggs. These filters have very high efficiency against Enterobacteria from 90 to 99.9% and 99 to 99.99% against Enteroviruses and Giardia cysts (Cotruro & Craum 1999)[Ref. 6]. SSFs also show more than 99.99% removal of worms and 99% to 99.9% removal of protozoa. However, SSFs require pretreatment preferably through roughing filters if the turbidity of the raw water is more than 50 NTU.

Multistage filtration (MSF) has advantages similar to SSFs in terms of ease of operation and maintenance, therefore, applicable to rural communities and small municipalities, where chemical treatment has no or very little potential. MSF may consist of two or three main stages (dynamic roughing filters "DyRF", upflow roughing filters "URF" and SSFs) depending on the level of contamination in the water source (see Figure 1).



FIG 1: Components of a Multistage Filtration System

DyRF are used for the waters with high suspended solids. URF can be avoided if good quality surface water is available. Roughing filters can reduce bacteria, worms and protozoa upto 90% but are not effective against viruses (NREL 1998)[Ref.20]. The results both on pilot and full-scale clearly indicate the great potential of MSF technology followed by disinfection to reduce the physical-chemical and bacteriological risk associated with surface water sources (Cotruro & Craum 1999) [Ref. 6]. Trained persons are required for smooth operations and monthly cleaning should be done to deal with high turbidity waters.

2.2 Boiling

Boiling is effective against microorganisms such as viruses, bacteria, cysts and ova. It is safe, time honored and effective method for household disinfection. To ensure full disinfection, water must be boiled for one minute at sea level. Add one further minute for each increase in altitude of 1000 metres (WHO 1996a) [Ref. 40]. Boiled water should be kept covered while cooling (Drinking Water Resources 2003) [Ref. 9]. However, the major obstacle in this case is the availability of fuel wood, especially dry wood during frequent rainy seasons in most of developing countries. In addition, fuel wood burning also contributes to deforestation and air pollution. Even if adequate fuel wood is available, the time and energy required for its collection make boiling drinking water less than appealing (Bourgoing, 1989) [Ref. 12]. Therefore, due to high energy costs and environmental issues it should be considered suitable only in case of emergent situations.

2.3 UV Radiation

Ultraviolet radiations are generated by an electrical discharge through mercury vapor, penetrate the genetic material of microorganisms and retard their ability to reproduce (Darby & Heath 1995) [Ref. 7]. In addition to the reduction in biological activity, UV light is also effective in degradation of a number of chemical compounds known to have adverse health effects (Watersolve 2003) [Ref. 36].

Complex and expensive UV treatment technologies, as used in developed world are not suitable for developing world. However, small-scale, energy efficient, cost effective and low-maintenance UV-waterworks for rural communities (with public stand posts type level of service, tested both at laboratory and field scale in India and South Africa) can disinfect water at a rate of 15 liters (approx. 4 gallons) per minute with minimum use of electricity (40 W). The device could serve a community of 1000 persons at an annual cost of 14 cents per person. This rapid disinfection (12 sec) technology does not need trained operators and require maintenance after every six months (Gardgil & Greene 1997) [Ref. 13]. Efficiency of UV is very high (greater than 99%) against bacteria and viruses, but poor against worms and protozoa. For surface waters filtration should always be done, because UV radiations cannot treat waters with high turbidity and Giardia or Cryptosporidium as well. Giardia cysts will survive UV treatment regardless of the system used for disinfection (Extension Bulletin 795, 2003) [Ref. 11].

UV does not work without electricity and produces no residual effect; therefore treated water should be consumed within 36 hours after the treatment (Gardil & Greene 1997) [Ref. 13]. Since there is no relevance of economies of scale in UV treatment technology, the cost of disinfection per cubic meter remains about $.02 even for small systems, while for chlorine treatment units the costs are comparably low for large-scale systems but increase with an order of magnitude as the scale gets smaller (Gardgil 1998) [Ref. 12]. ***UV treatment system can also be operated with photovoltaic (PV) modules, but this type of UV system should be sized as small as possible due to constraints of cost and lack of specific local meteorological data.***

Using ultra violet light from the sun is amongst the easiest and most sustainable method for drinking water disinfection for developing countries at household level. However, Solar Water Disinfection (SODIS) [Ref. 27] is now a well established technology and is reviewed separately in the next section.

2.4 Solar Water Disinfection (SODIS)

SODIS is a simple and cost effective process based on the synergetic effect of UV radiation and temperature to inactivate water-borne pathogenic microorganisms, especially those causing diarrhea at household level (Wegelin 1994) [Ref. 37]. Ultraviolet and infrared solar radiations are used to inactivate and destroy pathogens by exposing water filled in transparent plastic 1.5 or 2 liter mineral-water and soft drinks bottles made of PET (ploythylene terephtalate) in sunlight for 4 to 6 hours, however longer periods are necessary in cloudy condition which may be up to 2 days. Half black bottles can be used to increase the heat gain. The bottles may be placed at an angle to maximize their surface area exposed to the sunrays on the roof of a building or on a table built away from other structures. Aluminum or other metal sheets can also be placed underneath the bottles to cause reflection of the sun's rays into the bottle. For more information see (SODIS 1997) www.sodis.ch [Ref. 27].

2.4.1 Suitable Regions of Earth for SODIS

Semi-arid regions (over 90% of the sunlight reaches the surface of earth due to minimum cloud cover and usually more than 3000 sunshine hours/ year) located between latitude 15°N and 35°N (as well as 15°S and 35°S) and having highest amount of solar radiation are the most favorable regions for SODIS. Fortunately, majority of developing countries are located between latitudes 35°N and 35°S (SANDEC 2002) [Ref. 23]. Pakistan located at 30°N has about 3000 sunshine hours / year almost throughout the country. Sunshine hours of some major cities of Pakistan are listed in Table 1.

Table 1
Sunshine Hours of Different Cities in Pakistan

Sr #	City	Province	Sunshine Hours/ year
1	Islamabad	Capital	3132***
2	Karachi	Sindh	2977***
3	Lahore	Punjab	3038*
4	Peshawar	NWFP	2921***
5	Jacobabad	Balochistan	3255***
6	Multan	Punjab	2900**
7	Faisalabad	Punjab	2890**
8	Bahawalnagar	Punjab	2850**
9	Hydarabad	Sindh	2886**
10	Nawabshah	Sindh	3012**
11	Rohri	Sindh	3303**

* Hong Kong Observatory (Data from 1961 to 1990) [Ref. 4]
** Ullah & Habib, IWMI 2001 [Ref. 16]
*** BBC Weather 2006 [Ref. 1]

2.4.2 Limitations

Limitations associated with cloudiness and turbidity more than 30NTU may be mitigated through the use of solar disinfection in conjunction with solar kiln technology. Through the ability of the kiln's reflector to collect and focus solar radiation, greater levels of UV-A radiation can be brought to bear on the water container, thus it is possible that both the "processing' time and the ability to penetrate through high turbidity levels may be enhanced (Moore and Mclean 2005) [Ref. 19].

2.4.3 Economic Considerations / Sustainable Technology

The costs are divided into; a) cost of bottles and b) operating and maintenance cost. The latter ones are negligible, since solar energy is free of charge. The annual costs for a household of 5 persons is as low as 3 US$ (two bottles per person at a price of 0.3$ per bottle). Dissemination of the technology has to be through local institutions (NGOs, government and media) and the costs should be funded by the grants of donors or governmental services (Desa 1997) [Ref. 8].

2.4.4 Experience in Developing Countries

An NGO based Community Action Program (CAP) has been promoting SODIS in **Pakistan** in the province of Punjab including cities of Faisalabad, Gojra, Jhang, Rajoa, Chiniot and Lahore since 2002. Results showed that Pakistani government, local political and religious leaders, health practitioners and school teachers can play an important role in a successful introduction and implementation of the technology (SODISa) [Ref. 28].

In Tamil Nadu, **India**, a local women organization, "Lead for Education and Development (LEAD)", promoted SODIS through its existing network of Sagams (women self-help groups), schools and cultural programs. During project duration of 2 years, a total of 41,450 households and 99 schools had been trained in the application of SODIS and 111,600 PET bottles had been distributed. The survey on the acceptance of SODIS revealed that from the people trained there are 47.6% regular users, 45.2% irregular users and 7.1% non users (SODISb) [Ref. 29].

EAWAG/ SANDEC introduced SODIS to about 50 households in Thimi and Ratna Nagar (a small town in Chitwan district) in **Nepal** and found that, several visits to the community are required to achieve a sustainable application within the community, trainings should be done by locals and to a cluster of houses rather than a single house to enable people to exchange their experiences (SODISc) [Ref. 30].

In **Srilanka**, SODIS pilot project, the technology was introduced through 324 families through 46 community development workers in 21 communities in the districts of Hambantota, Anuradhapura, Polonnaruwa, Bathicola and Kandy. The study revealed that 81% of the SODIS users still practice SODIS, while 19% gave up the method (SODISd) [Ref. 31].

In **Indonesia**, SODIS was introduced to two villages Melikan and Dobalan. The monitoring and evaluation exercise conducted in May 2000 revealed that people were generally interested in SODIS, international agencies in Indonesia also started to adopt SODIS. However, people have some difficulties to understand the degree of cloudiness (SODISe) [Ref. 32].

Women group members gave some comments about SODIS use in **Kenya** in August 2001. They said that SODIS is very easy to use, there is no need of firewood now, very cheap, makes water safe (we no longer get headaches - associated with typhoid, amoebae, and

diarrhea) and our men like it as well as it supports us in our undertakings (Burgess 2001) [Ref. 5].

In April 2001 the Kokand branch of JDA (Joint Development Associates) started the SODIS pilot project in the Ferghana valley, in **Uzbekistan**. Note that, people in central Asia believe that drinking cold or not boiled water makes people sick, which puts SODIS in the category of raw or untreated water. Therefore there is a need to emphasize that the sun boils the water and the SODIS is treated water (Brunner 2001) [Ref. 3].

In October 2000, the Avina Foundation supported a major program for the promotion and dissemination of SODIS in seven **Latin American's countries** (Bolovia, Peru, Ecuador, Nicaragua, Handuras, El Salvador and Guatemala). Experiences with the demonstration projects have shown that it is very effective to spread and promote the technology at grassroots level though local leaders (Torrnes & Gremion 2000) [Ref. 34].

Ban Phu Lek and Ban Ning Rue Kae, two villages were selected in **Thailand** for SODIS pilot project in September 1996. A visit after 5 years in April 2005 showed that most villagers still apply SODIS (Somboonsub 2001) [Ref. 25].

2.5 Chlorination

Chlorine is an effective disinfectant and rapidly penetrates microbial cells and kills the microorganisms present tin the water. However, the effectiveness of chlorine is influenced by the physical characteristics; turbidity, concentration of disinfectant, the contact time and chemical characteristics, pH and temperature of water. The presence of suspended solids may protect pathogens and so reduce the disinfecting ability. WHO recommends for maximum turbidity level of 5 NTU for effective chlorination practices (WHO 1993 & 1996) [Ref. 39, 41]. This can be achieved through filtration.

Chlorine combines with water to form hypochlorous acid (HOCl) and hydrochloric acids (HCl). The hypochlorous acid (free available chlorine) formed is a weak acid and is 50 per cent dissociated at approximately pH 7.5 (Sawyer 2003) [Ref. 24]. To ensure effective disinfection, the pH must be maintained below 7.0, so that 90% of HOCl is in undissociated, active disinfectant form. However, most natural waters have a pH below 8.0 and thus disinfection by chlorine is rarely compromised by pH.

Chlorine practices depend upon the desired level of residual chlorine and the point of application are shown in Figure 2 for a conventional water treatment plant. Pre-chlorination to remove taste and odour is no longer in use, because it enhances the production of trihalomethanes (THMs) and other halogenated organics. However, small dosages of chlorine to maintain a small residual (0.1 mg/L) before filtration can reduce humic materials which are precursors of THMs and is helpful in reducing bacterial growth in the filter as well as in disinfection. ***Dosages of 0.25 to 0.5 mg/L are usually sufficient to produce residual chlorine content in both post-chlorination after filtration and plain-chlorination for ground water supplies. However, higher dosages may be required to ensure proper disinfection up to the consumer's end for high organic content (McGhee 1991) [Ref. 17].***

Contact time between chlorine and water varies with chlorine concentration, the type of pathogens present, pH and temperature of the water. Contact time must increase under conditions of low water temperature or high pH. Contact time of at least 30 min is recommended in the WHO Guidelines for drinking water quality (WHO 1993 & 1996) [Ref. 41, 39].

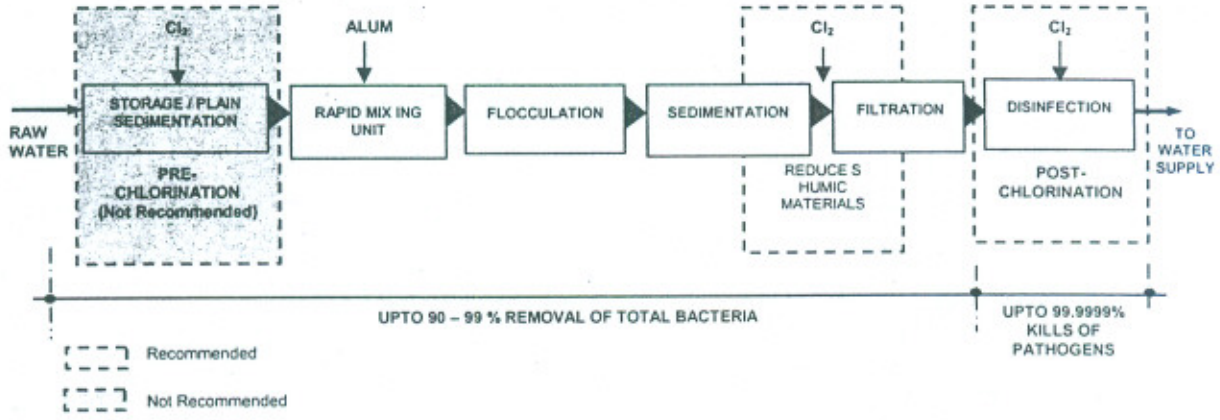


FIG 2: TYPICAL CHLORINE APPLICATIONS IN A CONVENTIONAL WATER TREATMENT PLANT

2.5.1 Disinfection (Chlorine) By-Products (DBPs)

DBPs are chemicals that result from the reaction of chlorine with organic substances in water. Trihalomethanes (THMs) refer to one class of disinfection by-products found in nearly every chlorinated public water supply to some extent. In 1991, the International Agency for Research (IARC) on Cancer evaluated the carcinogenic potential of chlorinated drinking-water and concluded that (IARC 1991a) [Ref. 15];

> ***"There is inadequate evidence for the carcinogenicity of chlorinated drinking-water in humans. There is inadequate evidence for the carcinogenicity of chlorinated drinking-water in experimental animals."***

Based on available research, WHO concluded that "the risks to health from DBPs are extremely small in comparison with inadequate disinfection", and urged that disinfection by chlorination not be compromised in attempts to control DBPs (WHO 1993) [Ref. 41]. The European Union (EU) is currently reviewing the Directive on drinking water. It is expected that chlorine will still remain as the preferred disinfectant (Euro-Chlor 1993) [Ref. 10].

2.5.2 Types of Chlorine for Rural Water Supplies

The chlorine is available in chlorine gas; sodium hypochlorite; calcium hypochlorite; chlorine produced on site by the electrolysis of a sodium chloride solution (electro-chlorination); and tablets of hypochlorite. Dangerous leaks of chlorine gas make it unsuitable for rural water supplies where handling and storage issues possess great importance. Sodium hypochlorite is most commonly used for disinfection in the home and in water supplies where transport of the solution is not a problem. Calcium hypochlorite (chlorinated lime, tropical bleach, bleaching powder, 'HTH') is a white powder containing 30 to 70 percent available chlorine. It is most commonly used as solution for the disinfection of rural and small community water supplies and in diffusion hypochlorinators or in tablet form for household use.

2.5.3 Chlorination Technology for Rural Water Supply

Groundwater obtained from shallow dug wells and springs considered to be the major source of supply for millions of people in small communities. A number of surveys have revealed that dug wells become quite frequently contaminated from human activities and birds

droppings as well. Disinfection of open wells can be achieved through either direct pouring of chlorine solution or pot chlorination (Woody) [Ref. 38].

Proportioning devices operated by skilled persons are used for small and medium pumped rural water supplies. Water from the source is pumped to an elevated service reservoir and supplied by gravity to the distribution system; a bleaching powder solution may be dosed as shown in Fig 3.

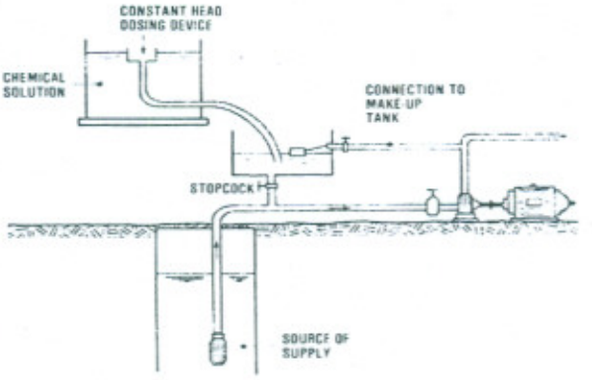


Fig 3: Proportioning devices for pumped supplies

2.6 MIXED OXIDANT GASES GENERATED ON DEMAND (MOGGOD) SYSTEMS

MOGGOD is the most recent arrival on the technical scene for drinking water disinfection. The basic concept is to electrically produce the mixed oxidant gases on demand using an electrochemical cell that uses industrial high-purity common salt (NaCl) brine as the chlorine source. The oxidant gases in the disinfecting liquid produced from electrolysis are a mix of chlorine dioxide, ozone, and hypochlorite. This liquid is then either metered into the source water or sold bottled to be added to household water storage tanks (Quick & Venczel 1996) [Ref. 21].

The main advantages of MOGGOD are that the source of the disinfectant is inert and relatively inexpensive (industrial high-purity NaCl), the mixed oxidants are a more effective disinfectant than chlorine alone, and a residual protection is produced in the water (Venczel 1997). One US manufacturer states that a mixed oxidant dose of 4 mg/l with a contact time of 60 minutes provides greater than 99.9999% disinfection against E.coli and viruses, and 99.99% disinfection of giardia cysts and protozoa (MIOX 1997) [Ref. 18]. Most of the experience with MOGGOD systems has been in Latin America. These systems are built and sold on demand, so prices are not stable (Reiff 1998) [Ref. 22].

The disadvantage of the MOGGOD system is that it requires dozens of hours of skilled maintenance per year of the electrochemical system, dosing valves, flow meters, and venturi ducts, including handling of caustic chemicals. Systems based on a membrane require cleaning and replacing the membrane every few months to a year (depending on the level of impurities in the salt), and so appear inappropriate for typical developing country applications (Gardgil 1998) [Ref. 12]. Continuous supply of salt and electricity can also cause problems sometimes in remote rural areas of developing countries.

3) COMPARISON OF DISINFECTION METHODS

Several methods of drinking water disinfection described above are compared for cost and suitability for both community supplies and household. Some of their results are summarized in Table 2. The three rural community level systems were assumed by Burch and Thomas in

1998 to include a roughing filter to reduce turbidity from surface waters before treatment (Burch & Thomas 1998) [Ref. 4]. The three home-use methods assumed no such pre-treatment.

Comparison done in Table 2 shows that chlorine with roughing filters for surface water sources is an appropriate technology for the small community water supplies with minimum requirements of skilled labour, moderate costs and good residual characteristics. Slow sand filter is another cost effective option with maximum ease of operation if supported with boiling and SODIS at household levels, because treated water has no residual disinfectant. Boiling is not economically viable for developing countries like Pakistan. Batch scale chlorine at home has some requirements of skilled labour and problems with availability of chlorine compounds all the times. At household level SODIS is the most cost effective and easy to use method for developing countries.

Table 2
Comparison of disinfection methods for small water systems

Sr No.	Parameters for comparison	Roughing Filter + chlorine dosing plant	Roughing filter + grid powered MOGGOD	Roughing filter + slow sand filter	Roughing filter + grid powered UV	Roughing filter + Photovoltaic (PV) powered UV	Batch scale chlorine for home	Boiling at home with purchased fuel	SODIS at home
1	Operating Cost (US cents / m3)	7	58	3	3	15	9	2083	0.6 $/ Person/ Year*
2	Effectiveness								
2.1	Residual	■	■	□	□	□	■	□	□
2.2	Against bacteria & viruses	■	■	■	■	■	■	■	■
2.2	Against protozoa & worms	▒	■	■	▒	▒	▒	■	□
2.3	With turbid waters	▒	▒	■	▒	▒	□	□	□
3	Ease of use								
3.1	Supply chain independence	□	▒	■	■	■	□	■	■
3.2	Independence from need for skilled labour	□	□	▒	▒	▒	■	■	■
3.3	Independence from need for unskilled labour	□	▒	□	■	■	▒	□	■
4	Environmental Sustainability	□	□	■	■	■	□	□	■

* The annual costs for a household of 5 persons is as low as 3 US $ (two bottles per person at a price of 0.3$ per bottle)

Sources
Burch & Thomas 1998 and NREL 1998

Legend:
High ■
Medium ▒
Low □
Nil □

In an independent and earlier study, the South Africa's Council for Scientific and Industrial Research (CSIR) compared UV, MOGGOD, and on-site hypochlorite generation in terms of their technical strengths and weaknesses, economics, and reliance on skilled labor. A study conducted by Solsona and Pearson concluded that each of these technologies has features that can be important for the overall water supply solution to small communities (Solsona & Pearson 1995) [Ref. 26]. Although none of the three is a perfect solution, none poses

insurmountable demands for maintenance and operational skill, and they all have high disinfection effectiveness. The study also concluded that a complete comparison will require field testing of all the three treatment technologies to see how they fare under actual field conditions.

4) CONCLUSIONS

i) Roughing filters supported by chlorine dosing plants for surface water sources and plain chlorination for ground water sources are rated as the most suitable technologies for small communities in developing countries. However, for rural water supplies, there is a need to develop more reliable and simple methods of chlorination, as well as simplified methods of monitoring and adjusting the chlorine residual in the product water.

ii) SSF is still the most cost effective method of disinfecting rural water supplies for developing countries. Due to no residual effect, treated water may become polluted within the distribution system; addition of residual chlorine requires skilled operators. Therefore a cost effective and easy solution is to disinfect treated water from SSF plant at the consumers end (at household level) through SODIS or boiling.

iii) Most of the SSF plants do not perform well during the rainy season in Pakistan due to high turbidity, therefore research is badly needed in the areas of multistage filtration/ roughing filters to be used as pretreatment devices in combination with the SSF technology to achieve effective disinfection for community water supplies in developing countries.

iv) Small scale grid powered UV-waterworks, which can work under small pressures (suitable for handpumps as well) and at a very low cost can be installed at public stand posts to disinfect clear surface and ground waters, or supported with filtration for turbid surface waters. Some field and laboratory work has already been conducted in India and South Africa, but more research work is required on this technology to reach the final conclusion about its feasibility for rural areas in developing countries.

v) Solar energy is the most cost effective and easy to use technology for household disinfection. This technology is being successfully used in Pakistan, India, Sri Lanka, Nepal, Kenya, Uzbekistan, Indonesia, Thailand and Latin America. Experience in developing countries reveals that government, political and religious leaders and schools can play an important role in the progress of the technology. Moreover it should be taken up at the policy level and disseminated through trained locals and media, because the people in developing countries generally believe in government recommendations.

vi) A shift of reliance from polluted surface waters to ground waters is another way to access safe drinking water. Remarkable advances have been achieved with publicly funded schemes in rural India with installations of 100,000 deep bore type hand pumps annually; with each hand pump serving about 200 persons (Talbott 1997) [Ref. 33]. Similar efforts are required to be made here in Pakistan and other developing countries with same socio-economic environments regarding development of hand pump technology.

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LOAD FORECASTING TECHNIQUES IN POWER SYSTEMS WITH SPECIAL REFERANCE TO DISTRIBUTION COMPANIES IN PAKISTAN

By

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ABSTRACT

Electricity supply being a large capital investment industry, needs an accurate load forecasting for realistic planning of new generation, transmission and distribution facilities. Load forecasting has some degree of uncertainty and rests on experience and good judgment, and requires that planners have a vision to think about the future systematically and with imagination. This paper addresses those areas of concern and provides a step by step systematic approach towards a realistic and fairly accurate power load forecasting techniques with special reference to Power System Distribution Companies (DISCO's) in Pakistan.

1) INTRODUCTION

An Electricity supply is a large capital investment industry. It is of prime importance that the planning of new generation and transmission and distribution facilities should be based on an accurate forecast. It should be prepared through reliable information of past energy and load demand. Power market survey are useful for planning different aspects of the power system.

The flow chart on Load Forecasting is a reference and reflects considerations a planner may apply [1]. Choice of influencing factors has been left to the discretion of the planner. In some cases, the planning material may not be available or have insufficient relevance to be included. From the probable things that may happen, the planner makes his choice of what should be included in the load forecast. In the final analysis, forecasting has some uncertainty and rests on experience and good judgment, and it requires that planners think about the future systematically and with imagination. Future customer loads are to be met keeping in view the following response time [1]:

a) 3-5 years lead time is required for building a new grid station or extension/augmentation of an existing grid station.

b) 11kV feeders can be built within one year.

In this work Energy and Demand Forecast of each distribution company has been computed.

The load forecasting process for the development and updates of detailed medium term plan requires has the following steps:

i) Regular annual updation.

ii) Review of historic load and projections from the most load value.

iii) Minimum dependence on influencing factors.

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2. FUTURE LOAD PROJECTION

2.1 Review of Actual Historical Data:-

In addition to looking at actual historical values and applying local knowledge, it is helpful to consider mathematically predicted future values. Then, the combination of judgment applied to historical values with consideration of projected values based on a consistent predication method, is of value to a planner.

Since the mathematical projection is not the sole input and since the actual values are not as consistent from year-to-year, there is often a need to "over-ride" a purely mathematically derived forecast in favour of local knowledge and good judgment.

If the yearly peak load data collected and plotted follows nearly consistent trend, then it reflects that the result will be fairly accurate. If one or more readings appear abnormal and deviate too much from the trend, these should be investigated for following;

i) Bifurcation of feeder or load transfers not recorded properly and load not adjusted accordingly.

ii) In-accurate figures in records due to meters or manual reading/recording errors.

If above factors cannot be investigated, the erroneous reading(s) shall be discarded and growth trend shall be established based on planner's local experience and good judgment and by applying the following:

a) In case only one erroneous reading is found, discard the reading and develop growth trend considering the remaining consistent peak load readings

b) If more than one historic reading seem inconsistent, take the most likely slope/rate of growth of the feeder and associate it with the most recent peak load.

2.2 Bottom to Top Approach

The preferred method to develop forecast is to project load growth on distribution transformers, to feeders to grid transformer, to grid station to sub transmission system, i.e. bottom to top approach. During these projections the trends at all levels have to be considered.

2.3 Grid Transformer Loading

The future loads shall be projected based on the last five years peak readings by drawing a trend line and finding its slope and taking into account the following:

i) Estimate the Grid transformer loading based on indicated growth rate to the year the transformers are projected to reach 80% of ONAF rating of the transformer. Same can be done for Grid Stations. A listing of the division capacity would indicate **a**) how much capacity is available or **b**) expected shortfall by the last year of the plan or earlier.

Take into forecast the future industrial loads to be supplied or existing industrial loads to be retired at 132kV, 66kV or 11kV.

ii) Loads which may be offset or removed/disconnected in future due to either new I.P.P's or new self generation resources on industries as well as demolishing of old areas or close out of existing industries.

iii) Load changes on feeders and grid station as a result of system rehabilitation and development projects completed in the preceding year or expected in service dates.

iv) Pending applications with DISCOs which represent growth of residential, commercial, rural and industrial consumers. This information is indicative of future load expended on the feeders and grid stations.

v) The projected load on transformers shall be adjusted for the past & planned load transfers in/out of the grid station.

A) Peak loads year by year for and of next five year can be mathematically predicted from the above by using slope of line (growth trend) and starting projection from the most recent peak load value.

B) The Distribution Planning Database of DISCO contains load data of feeders and grid transformers and forecasting algorithms are built in the database for load projections. Therefore, the database should be used for estimating future loads automatically. It is, however, necessary that the database is updated annually to include the most recent year peak load.

C) Repeat this calculation 'a' above annually to ensure updating and to drive schedule changes as required.

D) Modify, up or down the mathematically forecasted value by making adjustments for known load.

E) Print historic and projected future 5 year loads.

3) ECONOMIC FACTORS

Good engineering judgment and personal experience is important while considering the following economic factors which influence forecast.

- Utility energy upwards price trend lowers energy consumption.
- Interest rates, world market, personal income, price of other energy source, fuel prices, weather etc.

4) DEVELOPMENT OF DISCOs CAPABILITY TO HANDLE 132kV SYSTEM

4.1 Phase One

- The Load Flow Diagram (LFD) of each DISCO was prepared by Planning (Power) and sent in November, 2004.
- Each DISCO was asked to prepare LFD on daily basis Indicating the flows at the time of system peak.
- They were also requested to develop Voltage Profile (VP) and the Company Demand Sheet (CDS) at the time of system peak.

4.2 Phase Two

- All the DISCOs started making Load Flow Diagram (LFD) on daily basis.
- The LFDs are being checked regularly by Planning (Power) wing.
- All the DISCOs have also developed the Voltage Profile (VP) & Company Demand Sheet (CDS).
- The VP & CDS are being checked regularly by Planning (Power) wing.

4.3 Phase Three

Planning Department of each DISCO will carry out the following tasks:-

- Develop Monthly VP for Chief Executive & Chief Engineer/Technical Director of each DISCO.
- Develop Hourly Demand Sheet of DISCOs for preparation on daily basis.
- Calculate the total Energy Purchased as per CDS on monthly basis & the total unit sold.

4.4 Phase Four

- Calculate the losses on 132kV & 11kV separately on monthly basis.
- Circulate the Load Flow Diagram(LFD), Voltage Profile(VP) & Demand Sheet (DS) of the day when system peak occurred during the month after 100% Checking, to Senior Field Officers (S.E's / XEN's)
- Simulate the Load Flow of the day when System Peak occurred during the month on the PSS/E (computer) & perform the single line out contingency to assess system performance under normal and single contingency conditions.

LESCO LOAD DEMAND (MW)

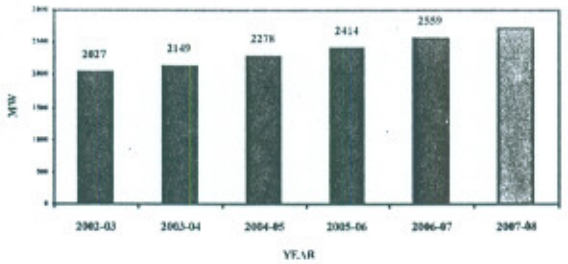


Figure: 1- LESCO Load Demand (MW)

5) USE OF FORECAST IN DEVELOPMENT PLAN

The reliability, efficiency and economy of a distribution system depends primarily on how well its grid stations, transformers and feeders are located within the DISCOs area and how well their capacities match power needs in their respective localities.

The above load forecast method when applied to different major components of distribution system will identify feeders or transformers which will be overloaded in the course of next five years.

5.1. Use of Forecast in Development Plan

The forecasted values shall be used to

1. project feeders and grid station loads.
2. examine feeder and grid station transformers for violations.
3. examine for available capacities of feeders and grid station transformers.
4. validate the observed problems and determine solutions appropriate to the violations

6) STANDARD OPERATING PROCEDURE FOR 11kV CAPACITOR

For the rehabilitation / up-gradation of H.T Network and for stable power supply against the anticipated load, proposed to be injected in the system, standard policy has been formulated which must be adhered to while conducting analysis of the Network:

6.1 First Option

a) Fixed shunt capacitors are to be simulated at the most appropriate location in the circuit, if capacitors are available in LESCO stores. In case of mixed load feeders, behaviour of Capacitor Bank during off-peak hours, must be checked and both the positions i.e "Peak Load Position" and "Off-Peak Load Position must be precisely checked as per procedure laid down in Distribution Rehabilitation Planning Guideline which is reproduced in Table 1:

TABLE 1
11kV Capacitor Judgment Factors
(Minimum kW Saving)

CAPACITORS	RURAL	URBAN
FIXED CAPACITORS	(saving at off peak)	
450 KVAR	1.2kW	1.2kW
900 KVAR	1.6kW	1.6kW

b) Size of the fixed capacitor, to be installed on a feeder, should be estimated at off peak load and if the saving is more than the lower limits given in the above matrix, the capacitor may be proposed, otherwise, find out other location or drop this option and seek other option.

c) If off peak load of the feeder is not available, then its 1/3rd of the peak load may be taken for calculation purposes.

d) Fuse rating for 11kV Capacitors is given as under:

TABLE 2
Fuse Rating for 11 kV Capacitors

Fuse rating	11kv Capacitor Rating (kVAR)	Colour
20K	300	Yellow
40K	450	Grey
80K	900	Violet

6.2 Second Option

After exhausting the first option, re-conditioning of the network, may be proposed to bring the parameters within permissible and safe limits.

6.3 Third Option

Bifurcation/Area Planning as per hierarchy given in the Distribution Re-habilitation Planning Guideline may be followed after second option.

The said hierarchy is reproduced briefly as under:

7) METHODS/TOOLS OF DISTRIBUTION REHABILITATION (HIERARCHY)

(Rehabilitation/Augmentation of HT Distribution Network)

Step-1 Area planning without addition of new feeder i.e. shifting of load from heavily loaded feeder to the adjoining lightly loaded feeders in the vicinity.

Step-2 Installation of HT shunt capacitors.

Step-3 Reconductoring i.e. replacement of existing conductor with higher capacity conductor.

Step-4 Bifurcation of feeder i.e. addition of new feeder, to shift some of the load of exiting feeder.

Step-5 Area Planning with addition of new feeders.

Step-6 Sometimes, Area Planning at grid station level is also required to provide relief to the over loaded grid stations by shifting its load to nearby under loaded or newly constructed grid stations. Area Planning may or may not involve new feeders.

LESCO Historical Peak demand is shown in Figure 2. Country load forecast is given in Annexture-I

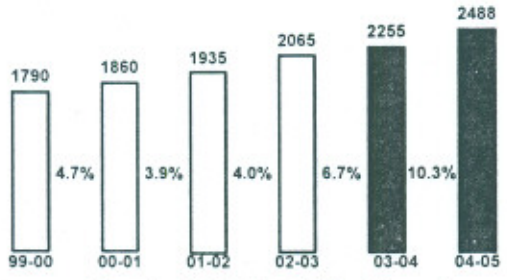


Figure:2 LESCO Historical Peak damand.

Figure 2 - LESCO Historical Peak demand.

8) CONCLUSION

Year wise load flow cases of the DISCO shall be prepared starting from the existing system load flow case, and the load flow cases for the load forecast for each year to be studied. The existing system load flow data on PSS/E shall be kept up-to-date. The data for the new projects shall be incorporated into the existing load flow data as soon as the project is commissioned. Following data may be additionally useful, i.e.

- New grid station
- Transmission line
- Addition of a new transformer in an existing grid station.
- Replacement of an existing transformer with a large size transformer.
- New generator.
- Modification / Change in the existing system.

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Annexure - 1

COUNTRY LOAD FORECAST

(MEDIUM TERM DEVELOPMENT FRAMEWORK)

Year	WAPDA			KESC			Capacitive			COUNTRYT			
	Sales GWh	Generation GWh	Demand MW	Sales GWh	Generation GWh	Demand MW	Sales GWh	Generation GWh	Demand MW	Sales GWh	Generation GWh	Load Factor	Demand MW
2004-05	53620	70270	12063	8240	13083	2050	6307	6710	1094	66094	87992	68.7	14621
2005-06	57757	74602	12806	8941	13385	2102	7009	7456	1216	71520	93257	68.6	15511
2006-07	62594	79740	13688	9752	13447	2114	7864	8365	1364	77905	99247	68.6	16526
2007-08	68199	85703	14712	10709	14770	2326	8875	9441	1540	85352	107484	68.5	17904
2008-09	74525	92966	15935	11782	16250	2566	10055	10697	1744	93800	117351	68.6	19534
2009-10	81770	101260	17356	13019	17956	2839	11429	12158	1983	103516	128673	68.6	21426
G.R (2005-10)	*8.81%*	*7.58%*	*7.55%*	*9.58%*	*6.54%*	*6.71%*	*12.62%*	*12.62%*	*12.62%*	*9.39%*	*7.90%*		*7.94%*
2010-11	89739	110326	18910	14368	19816	3133	12968	13796	2250	114226	141089	68.5	23496
2011-12	98562	121173	20770	15867	21884	3460	14698	15636	2550	126124	155690	68.5	25929
2012-13	108039	132824	227867	17472	24098	3810	16605	17665	2081	138950	171421	68.5	28550
2013-14	117552	144519	24734	19105	26350	4166	18531	19714	3215	152020	187415	68.6	31185
2014-15	127224	156410	26769	20771	28648	4529	20561	21874	3567	165384	203760	68.6	33912
G.R (2010-15)	*9.24%*	*9.09%*	*9.05%*	*9.79%*	*9.79%*	*9.79%*	*12.46%*	*12.46%*	*12.46%*	*9.82%*	*9.63%*		*9.62%*
2015-16	136775	168152	287798	22423	30926	4890	22611	24055	3923	178634	219958	68.6	36614
2016-17	146609	180242	30848	24143	33299	5265	24827	26411	4305	192400	236773	68.6	39418
2017-18	157216	193282	33080	26023	35892	5675	27332	29077	4742	207390	255069	68.6	42468
2018-19	168716	207421	35446	28088	38740	6125	30173	32099	5235	223792	275075	68.6	45751
2019-20	181272	222857	38084	30362	41876	6621	33373	35504	5790	241819	297049	68.6	49408
G.R (2015-20)	*7.34%*	*7.34%*	*7.31%*	*7.89%*	*7.89%*	*7.89%*	*10.17%*	*10.17%*	*10.17%*	*7.89%*	*7.83%*		*7.82%*
2020-21	195095	239851	40988	32896	45372	7174	37033	39397	6425	261832	321428	68.6	53466
2021-22	210507	258799	44226	35752	49310	7796	41246	43879	7156	284309	348792	68.6	58018
2022-23	227714	279954	47842	38976	53756	8499	46118	49061	8001	309068	379572	68.6	63139
2023-24	246775	303386	51846	42587	58738	9287	51689	54988	8967	337847	413909	68.6	68849
2024-25	267652	329053	56232	46587	64255	10159	57995	61697	10061	369026	451797	68.6	75149
G.R (2020-25)	*8.11%*	*8.11%*	*8.11%*	*8.94%*	*8.94%*	*8.94%*	*11.69%*	*11.69%*	*11.69%*	*8.82%*	*8.75%*		*8.75%*
AVG. G.R *(2005-2025)*	*8.37%*	*8.02%*	*8.00%*	*9.05%*	*8.28%*	*8.33%*	*11.73%*	*11.73%*	*11.73%*	*8.98%*	*8.52%*		*8.53%*

INTERRUPTION ON WAPDA DISTRIBUTION SYSTEM AND REMEDIAL MEASURES

By

Prof. Dr. Suhail Aftab Qureshi[1], Abbas Ali[2] and Zahir J. Paracha[3]

ABSTRACT

Frequent power breakdowns and unreliable electric supply from WAPDA Distribution System is a significant contributing factor to slow pace of development and relatively poor industrial growth in Pakistan, apart from badly effecting the performance of sensitive electronic equipment and gadgets of modern information infrastructure. This is resulting in ever-increasing customer complaints, calling for very high standards of service from electric utilities. This paper identifies major causes of power interruption on WAPDA's Distribution System and suggests different measures to tremendously reduce the frequency of such interruptions.

1) INTRODUCTION

One significant contributing factor to Pakistan's slow pace of development, in general, and relatively poor industrial growth, in particular, is the frequent power breakdown and unreliability of electrical power supply.

Unscheduled power shutdowns and momentary tripping are incompatible with the reliable power requirement of modern information infrastructure.

Increasing number of pollution creating electrical and electronic loads are being connected to the electrical distribution system. Due to this customers complaints about power supply interruptions effecting the performance of their sensitive electronic equipment is increasing day by day.

Hence power supply interruptions is a growing concern in electric distribution system. Customer because of the technological development are using sensitive and computer controlled loads. As a result very high standard of services is required from electrical utilities.

2) CAUSES OF POWER SUPPLY INTERRUPTIONS ON WAPDA DISTRIBUTION SYSTEM AND THEIR REMEDIAL MEASURES

There are six main categories of causes of interruptions in WAPDA Distribution System which comprises of several sub-causes. The main causes are as under: [Ref.1]

1. Technical
2. Organizational
3. Weather and Environmental
4. Accidental & Theft
5. Operational & Managerial
6. Customer's Installation

[1] UET Lahore, Pakistan
[2] SDO WAPDA Pakistan
[3] GM (Acad), IEVETA, Lahore

2.1. Technical Causes

These causes relate to some technical aspects and comprises of the following;

- Frequency Depression
- Transformer & Bus Bar Faults
- Breakage of Conductor & Jumpers
- Defective Switchgears
- Faults in Capacitors
- Puncturing of Insulators
- Faulty Cables / Services / Meters
- Improper Fuses
- Built-in Faults

2.1.1 Frequency Depression

General load trend in Pakistan can be seen by the load curve shown in Figure1. To meet this load demand WAPDA generate power from power stations. The load on these power stations varies with system load demand. If the load demand increases beyond generating capacity, the system frequency decreases. If the depression of frequency goes down to 49.6 c/s, the forced load shedding occurs through under frequency relays, causing interruption in supply. To control such a situation, the addition in generation is desired on urgent basis. [1]

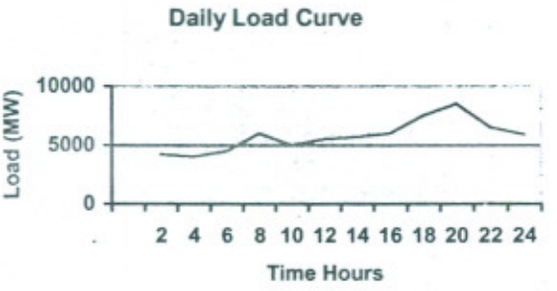


Fig - 1: Daily Load Curve [1].

2.1.2 Transformer & Bus Bar Faults

The faults in transformers and bus bars may cause a major interruption of supply to the consumers. These faults may be due to:

a) Insulation failure.
b) Flash over on bushings & insulators.
c) Damage of winding & sparking on the bus bar.
d) Phase to phase & phase to ground faults.
e) Break down of the conductor, joints & clamps.

The remedial measures to be taken are the periodic inspection, testing, checking and the regular effective preventive maintenance. Also transformers and bus bar must not be loaded beyond their rated capacity.

2.1.3 Breakage of Conductor & Jumpers

The conductor carries the electric power from the power house to consumer's premises where it is utilized. In our electric supply system aluminum conductor is being used due to its lesser cost, weight and softness as compared to copper. But is brittle than the copper so its breakage is most frequent.

The jumper and joints are the weakest parts of our distribution network. Besides the interruption in power supply, the breakage of conductor and jumper is dangerous for human lives and it may damage the property also, so remedial measures must be taken to minimize these faults. For this purpose:

a) Periodic preventive maintenance as well as the night patrolling of the lines should be carried out to observe the heated and sparking points.

b) The conductors must not be over loaded beyond their rated capacities.

c) The proper sleeves, clamps and connectors should be used and improper joints and jumpers should be replaced to avoid the breakage of conductor and the interruption in supply.

2.1.4 Defective Switchgears

The switchgear is used for interrupting overload and fault currents, and to remove the loaded equipment from service prior to isolation. The strength of the switchgear is its ability to provide an effective and protective means for the safety of the generators, transformers, transmission lines and the distribution network. Improper plug setting and malfunctioning is a cause of interruption in power supply also. [2]

2.1.5 Faults in Capacitors

Voltage stability and a high power factor are required by both the WAPDA (Water and Power Development Authority) and consumers. Static capacitors play an important role in meeting these demands. Various faults get developed in the capacitors because of an interruption in power supply, the most commonly causes are:

a) Breakdown of the dielectric strength and short circuiting inside the capacitor.

b) Damages of the bushing insulators.

c) Open circuiting causing imbalance of voltage.

The remedial measures to be taken are the periodic testing, checking and the preventive maintenance of the capacitors.

2.1.6 Puncturing of Insulators

It is observed that most breakdowns on transmission lines occur due to puncturing of insulators. It is very difficult and time consuming exercise to trace out such faults specially in sandy, hilly or waterlogged areas and equally difficult to rectify. Such faults may be minimized by checking the rupturing capacity during inspection at the time of purchase by the department and installation by the line staff.

2.1.7 Faulty Meters, Cables and other service ithems

These are used to supply electricity to customers. If there is some fault in them, it will effect the supply system. Special care must be observed for proposing and installing the service cables and meters and the assessment of load is necessary before their installation.

2.1.8 Improper Fuses

Various devices are being used for protection of electrical equipments. Fuses are cheapest and the most important in these items. It is being used for protection of distribution transformers, industrial and domestic appliances. Fuses are also used to sectionalize the 11KV feeders. It protects the transformers from overloading and short circuiting. So the proper size fuses must be used for stable supply system and in order to save the equipment from damage.

2.1.9 Built-In Faults

Whenever a new line is erected by construction or operation staff, they do not take into consideration the WAPDA Specifications, excessive sag, improper clearance etc. cause tripping on the supply system.

2.2. Organizational Causes

In organizational category, load shedding and shut downs are vital ones [1,2,3].,

2.2.1 Load Shedding

WAPDA has to carry out load shedding due to the following reasons:

a) Inadequate generating capacity
b) Maintenance of equipments
c) Emergency created due to breakdown
d) Dam regulation for canal closures

To meet with the demand we should increase the generation capacity.

2.2.2 Shut Downs

Shut downs are arranged to carry out preventive maintenance of the electrical equipment and to attend breakdowns. It should be arranged in such a way so that minimum time is taken to complete shut down and these should be properly coordinated and published through the news media for the information of general public [1].

2.3 Weather & Environmental Causes

Climatic effect of nature plays major role in the continuity of supply. These effects are as under:

2.3.1 Lightning, Rains & Wind Storm

The feeders whose maintenance has not been carried out are badly impacted due to climatic effects. Therefore it should be ensured that the loose sags of conductors are stretched, jumpers are tightened so that the feeders should withstand pressure of rains & wind storm.

Lightning damages the transformers and other apparatus if proper earthing is not provided.

2.3.2 Fog and Snow Fall

As our H.T/L.T transmission lines pass through water logged coastal and hilly areas, therefore fog and snow fall affect efficiency of transmission lines. In order to withstand the effects of fog and snow, sufficient clearance is required so that the line may not be earthed. Therefore pins of higher size and special type insulators may be installed on the lines.

2.3.3 Trees, Kites & Birds

Touching trees result in earthing due to which electric supply is failed. It is therefore necessary that tree trimming / tree cutting be carried out periodically.

Kites are another cause of supply interruptions. It is necessary to arrange shut downs to clear lines from the kites / threads.

Power supply is also interrupted due to birds. It is therefore necessary to provide sufficient clearance between phases, line and earth. Jumpers of distribution transformers should be insulated.

The suitable way to avoid interruptions due to above reasons is to lay down under ground power cables.

2.4 Accidental & Theft Causes

The category of accidental and theft causes comprises of accidents with lines and theft of conductor. Detail is as below:

2.4.1 Accidents With Lines

Due to striking of any vehicle with the structure / pole, the pole is tilted or collapsed and some time even the conductor break-downs occur causing interruption in supply. This can be avoided by providing projected foundations or safe guards etc.

2.4.2 Theft of Conductor/ Transformers

Sometimes in remote areas due to theft of conductor or transformers etc. the supply is interrupted and it takes too many days to restore the supply because of lengthy departmental procedures.

This can be avoided by periodic checking and patrolling of lines in remote areas at night and welding the transformers to their platforms.

2.5 Operational & Managerial Causes

Operational and managerial causes comprise of inefficient and unskilled workers, lack of communication and coordination, shortage of T&P, material and vehicles. Detail is as below [1]:

2.5.1 Inefficient and Unskilled Workers

Whenever any unskilled lineman operates the D-fuses whether on section or transformers, the supply is interrupted due to his lack of experience. Similarly due to slackness of line staff

it takes much time to restore the supply. This can be overcome by training the line staff properly.[3]

2.5.2 Self Operation of D-Fuses

In remote areas particularly in tubewell operational areas, the WAPDA line staff do not attend the complaints immediately due to various reasons so the customers themselves operate the D-fuses of their transformers and due to improper touching of fuses, it not only causes supply interruption but some times fatal accidents may also occur.

This can be avoided by improving the WAPDA staff efficiency and taking legal action against unauthorized persons operating the fuses [1].

2.5.3 Lack of Communication & Coordination

Whenever telephone of either side is out of order, then there is no alternate way for the grid station staff to inform the operation sub divisions about the feeder tripping and if there is lack of coordination between GSO (Grid Station Operation) staff and operation, then it takes a lot of time to restore supply.

This can be minimized by providing the mobile facilities in addition to telephones at sub divisions and grid stations and also to hold coordination meetings between GSO & Operation staff.

2.5.4 Lack of T&P, Material & Vehicle

S.D.O or XEN has no power to purchase any T&P items or material. So even for a minor item, the supply remains OFF for a long time. As the vehicle situation is not healthy in the sub divisions, so the line-man has to travel on bicycle or on foot to restore supply, causing delay in restoration. This cause can be over-come by delegating the powers to the field officers for purchase of T&P or other emergency materials. [2]

2.6 Customer's Installation Causes

The sixth category identified is customer's installation causes due to customer's unauthorized extensions of buildings/sheds and loads. Details is as below:

2.6.1 Illegal Extension of Building/Shed

Another cause for system interruption is defective installation at the consumer premises. These defects may arise after passing some period or at the time of installation. The defects can be observed in the internal installations or at the appliances connected with the system. [3]

There are many reasons for these defects:

a) Use of under gauge and poor insulated cables / wires.
b) Non providing of control devices for over loading.
c) Non-providing of earth to appliances and internal wiring.

To overcome this problem, it is necessary to educate the people to stay away from lines for their own safety and continuity of supply and strict action should be taken. Such consumers should not be given electric supply who against defaulters resort illegal extension.

2.6.2 Illegal Extension in Customer Installation/ Premises

One of the causes which reflect into interruption of supply is due to illegal and unauthorized extensions made by the customers/public. Due to such illegal extensions, the supply system is interrupted at one side and on other side human lives are also lost.

To overcome this problem, the load limit devices be installed and if any customer exceeds his load his supply be disconnected and be punished with fine and should not be given supply for certain period as a punishment to set an example for others [1].

3) CONCLUSION

After going through all the causes of power interruption of WAPAD supply it can easily be observed and concluded that there are many reasons for interruption in the power supply.

However by taking measures, as suggested, with all different causes of interruption, the frequency of such happenings can be reduced greatly.

Therefore it is recommended that WAPDA should amend their policy, particularly on operation and managerial issues, according to the suggestions, given in this Paper.

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COASTAL REGION OF PAKISTAN – VULNERABLE TO TSUNAMIS

By

Prof. Dr. S. M. Makhdumi[1], Mr. S. A. A. Kazmi[2], and Ms. Qudsia Saba[3]

1) INTRODUCTION

Pakistan is among the countries where coastal region is vulnerable to many natural hazards like floods, rains, cyclones, earthquakes, and tsunami etc. These natural disasters can cause huge loss of life and property. Of all natural disasters, earthquake is the most devastating calamity known to human being. It has done more damage to life and property than any other natural disaster in the past. The latest global statistics show that an earthquake takes an average yearly toll of 15000 to 20000 lives.

2) EARTHQUAKES IN COASTAL REGION OF PAKISTAN

Coastal areas of our country lie along some known fault lines like Murray ridge and Makran coast of North Arabian Sea, Kirthar and P.A.B ranges of Baluchistan, Sarjan and Jhampir of Sindh and Jati-Allahbund Range of Runn of Kutch .Karachi the mega city of Pakistan is affected by most moderate, major earthquakes occurring on these fault lines but have not caused any damaging effect as the intensity of earthquake at Karachi did not exceed "5". Study of seismic data (1905-2004) carried out at Sir Syed University of Engineering & Technology has revealed that about 40 earthquakes of magnitude ranging between 4 to 8 on Richter Scale occurring in the region were felt in Karachi as it is within the radius of perceptibility of these shocks. Their effective intensity at Karachi as worked out is tabulated below (Table 1) :

Table 1

Number of Earthquakes	Category	Magnitude	Intensity at Epicenter "Ie"	Intensity at Karachi "I_k"	Effect in Karachi
26	Minor	3 to 4.9	3 to 6	3 to 5 aqccording to Modified Mercalli Scale	Felt in Karachi however no damage was reported
10	Moderate	5 to 6.9	7 & 8		
4	Major	7 to 9	9 to 11		

The Major earthquakes which completely destroyed vast areas around the epicenter are the well known earthquakes of

- Makran coast in 1945 & 1947
- Khuzdar in 1931
- Rann of Kutch in 1819 , 1956 and 2001

The above mentioned earthquakes were felt at Karachi but no damage was reported as their effective intensity at Karachi ranged between 3 and 5. All were moderate and originated at a distance of more than 100Kms from Karachi.

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3) EARTHQUAKES IN SINDH

The province experienced devastating earthquakes in the past. The Sarjan and Jhampir faults were very active some 5000 years ago. Several devastating earthquakes of intensity 10 & 11 continued to affect the region over several hundred years, and completely devastated the upper Sindh areas. Devastating earthquakes damaged the city of Moen-jo-Daro and Bhambore several times and th> thickly populated and the flourishing town of Moen-jo-Daro was ultimately buried under debris. Fig. 1 shows the occurrence of location of major earthquakes in South Sindh / Baluchistan.

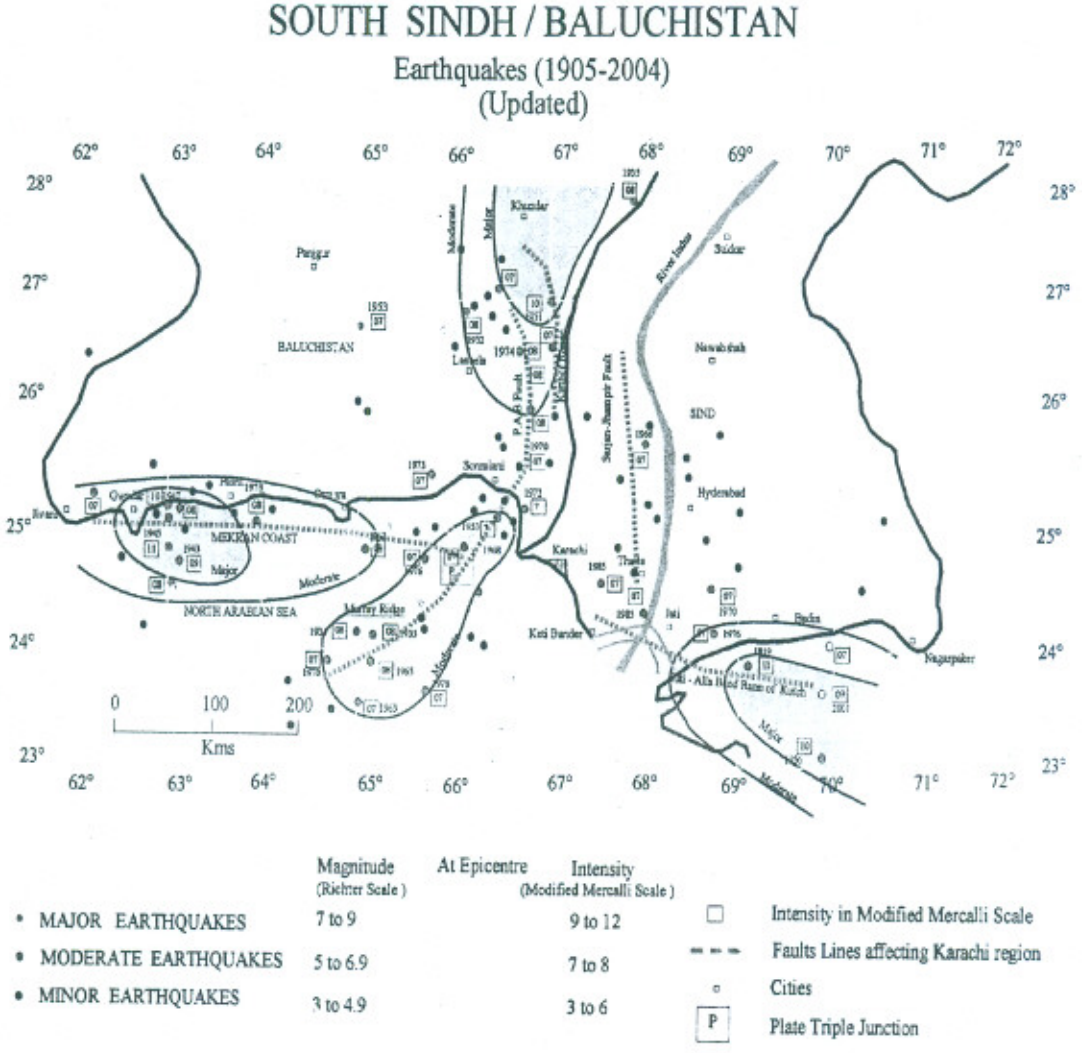


Fig. 1 SEISMIC MAP OF SOUTH SINDH / BALUCHISTAN SHWOING EARTHQUAKES (1905-2004)

However the trend of occurring earthquakes in these areas has drastically reduced during the last three hundred years. Last 100 years of seismic record shows the occurrence of only three earthquakes of moderated intensity "7". Two of these originated near Thatta in 1985 and felt in Karachi. Many earthquakes of minor intensity have continued to be attributed to gradual stabilization of the underground tectonic structures along the fault lines in the area.

Rann of Kutch is still treated as an active seismic region because of long earthquake occurrence history. The major earthquakes which had caused widespread damage to both

life and property were experienced in 1891, 1956 and 2001. Coastal region of Sindh which includes the cities of Badin, Thatta, Keti – Bander, Nagar Parker etc. is affected by earthquakes occurring along active faults of Allah Bund-Jutti.

4) EARTHQUAKES GENERATING TSUNAMI

Tsunami a huge harbour wave can be generated by the occurrence of earthquake in sea of coastal waters. Tsunami when generated causes havoc because of its unusual height (20 – 30 m) and speed (400 – 500 Km / hr) capable of sweeping islands, hitting coastal belts and causing colossal loss of life and property. From the records of the history, major earthquakes occurring in the North Arabian Sea were responsible for Tsunami generation and resulted in major damage in Makran Coast in 1945 and Rann of Kutch coastal regions.

The loss of life in these Tsunami disasters was in thousands although the areas of Makran coast / Rann of Kutch were thinly populated. Luckily these Tsunamis did not cause measurable damage to Karachi coastal belts because of low tides at that time.

5. IDENTIFICATION OF COASTAL REGION OF THE COUNTRY VULNERABLE TO TSUNAMI DISASTER

In the light of the past history of Tsunami affecting the coastal areas of North Arabian Sea during the last few centuries detailed seismic studies of the region were undertaken to update our existing knowledge of the phenomena and develop latest methodology to forewarn the people in advance in case a danger of Tsunami hitting the coastal region is foreseen. Seismic Map (Fig. 1) shows the earthquakes of three categories (Major, Moderate and Minor) affecting the vulnerable region of South Sindh / Baluchistan and North Arabian Sea during the last 100 years (1905-2004). The isoseismal lines / curves show three active seismic regions namely Mekran coast, Rann of Kutch and Murray Ridge where major earthquakes can occur any time in future. The inferences drawn from the study in respect to the three vulnerable regions are summarized below.

5.1 Makran Coast

It has been noted by SSUET that during the last 100 to 200 years where as numerous major earthquakes have occurred in the Indian Ocean and North Arabian Sea, the frequency of generation of Tsunami by such earthquakes has been small - only once or twice in a century. Makran Coast has already experienced two Major earthquakes in 1945 and 1947 with Tsunami hitting the coasts and causing heavy loss of life and property. The coastal area of Makran being in the seismic belt is likely to continue experiencing and earthquakes in future. All earthquakes do not generate Tsunami and even if a Tsunami is generated, it is not likely to affect Karachi Coastal region.

5.2 Rann of Kutch

Rann of Kutch is an active seismic region and has generated Tsunami in the past. The region in the past comprised of an island surrounded by sea water as seen in Fig. 2. Major earthquakes occurring in Rann of Kutch generated Tsunami.

The sea water surrounding the island has gradually filled up during the past 100 years with solid rocks and has taken the shape as it exists today. We predict that the remaining portion 'A' is also likely to be filled up gradually in due course of time. Tsunamis are not likely to be generated now when earthquakes occur in Rann of Kutch. This is evident from the record of later major earthquakes occurring in 1956 and 2001. The Southern coast of Sindh / Karachi is therefore, no more vulnerable to Tsunami from Rann of Kutch earthquakes. However

South eastern region of the Sindh Coast will continue to experience minor to moderate earthquake whenever a major earthquake occurs in the seismically active region of Rann of Kutch. They may even suffer same damages from such earthquakes.

5.3 Murray Ridge

Earthquake occurrence record of the last 100 year (1905-2004) in South Sindh / Baluchistan and North Arabian Sea establishes the presence of an active seismic region in Murray Ridge area located about 100 to 200 Kms southwest of Karachi. This region according to statistics has, during the last 40 years experienced more than twenty (20) earthquakes mostly of intensity "7" and "8" on modified mercalli scale. The frequency and intensity of these earthquakes depict an increasing tendency. A seismic report issued by Indian scientists after Sumatra quake of 26th Dec 2004 stated that Arabian Sea, about 70-100 Kms off Karachi – Baluchistan coast, was vulnerable to the generation of Tsunami. There is, therefore, an urgent need to install a set of automatic digital seismometers for monitoring the seismic activity of the Murray Ridge area and to develop and install a disaster "Warning System" in Karachi.

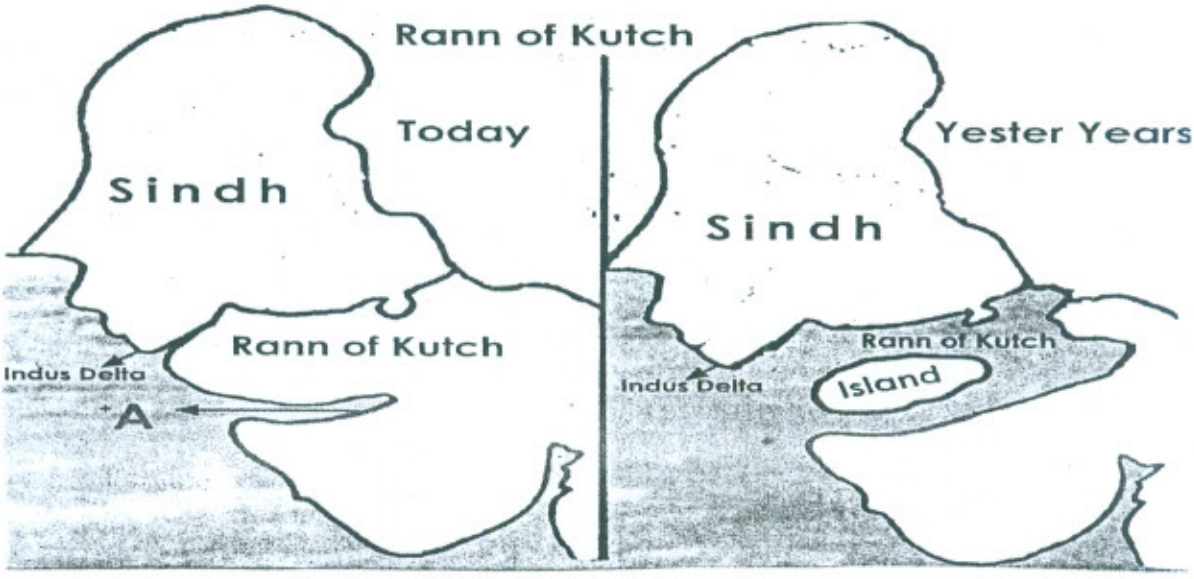


Fig. 2 Change in the Rann of Kutch over time as seen today and in the Past.

According to the isoseismal lines three known active fault lines "A", "B", and "C" are seen converging at a point in Murray Ridge area which for the purpose of identification can be described as "Plate Triple Junction". From the seismic analysis, inference is drawn that this region is a real threat for Karachi Coast for Tsunami should a devastating earthquake originate in the area.

The identification of the vulnerable areas of coastal region makes it easier to choose the points for the installation of the Warning system along the Sindh / Baluchistan coast. Since the region lies at the junction of three seismic faults it is vulnerable to the occurrence of major earthquake which may generate Tsunami with devastating high tidal waves.

Since Tsunami warning system works be in real time frame of short duration, time factor is of vital importance for minimizing the colossal loss of human life, Quick and accurate assessment and interpretation of earthquake is essential so that warning reaches the inhabitants before the calamity hits the region. For the proper relay of the Warning System, determination of demographic distribution of population along coastal belt is essential to minimize losses.

The Institute of Human Settlement and Environment which is primarily a research Institute of Sir Syed University of Engineering & Technology has, purely as a public service, involved groups of final year students for detail survey of the coastal belt of Karachi.

Survey includes the details about the following:

1) Distribution of population from official records of Nazims, Cantonment areas, Coastal Development Authority, private owner ship housing societies etc. along islands located in the coastal belt.

2) Identification of public utility organizations like hospitals, clinics, schools, mosques, police stations, and fire brigade stations.

3) Availability of public utility services and facilities like water-supply, electricity, gas, sanitation, transport, radio, T.V. area wise. Whether all these facilities are provided by Government or by private agencies, housing societies etc.

4) Locating high level of grounds or buildings where the residents can move.

5) Accessibility information of the natives of the islands to the main coastal belt.

The Institute of Human Settlement and Environment has also prepared the guidelines for the awareness of Tsunami so that the destruction and losses can be minimized.

6. PREPAREDNESS FOR TSUNAMI

If a major earthquake or landslide occurs close to shore, the first wave in a series could reach the beach in a few minutes, even before a warning is issued. Areas are at greater risk if these are less than 25 feet above sea level and within a mile of the shoreline. Drowning is the most common cause of death associated with a tsunami. Tsunami waves and the receding water are very destructive to structures in the run-up zone. Other hazards include flooding, contamination of drinking water and fires from gas lines or ruptured tanks.

The following are the guidelines which can be followed by the people if the region is hit by Tsunami waves, these will help the natives to protect themselves and their families from the destruction of the phenomena.

6.1 What to do before a Tsunami

1. Learn the terminology used by the officials of the government agencies related to phenomena.
2. Listen to radio or television for more information and follow the instructions of the local authorities.

   Contact Coast Guard's emergency information centre for updated local authorities report.
3. Immediate warning of tsunamis sometimes comes in the form of a noticeable recession in water away from the shoreline. This is nature's tsunami warning and it should be heeded by moving inland to higher ground immediately
4. If you feel an earthquake in a coastal area, turn on your radio to learn if there is a tsunami warning.
5. Plan, in advance, an evacuation route from your home, school, workshop or any other place you may be. If possible pick an area about 50-100 ft. above sea level and climb up.

6. If no high rise building or hill is available on or near the coast, walk up 1-2 miles on foot within 15 minutes. Local emergency management officials can help you to the best route to safety.
7 Know that a small tsunami at one beach can be a giant wave a few miles away. The topography of the coastline and the ocean floor will influence the size of the wave.
8. Tsunami is a series of waves which continue for hours. Don't assume that after one wave, the danger is over. The next wave may be large than the first one.
9. Prepare to evacuate if announced by the authorities.

6.2 What to do during a Tsunami

1. If you are advised to evacuate, do so immediately.
2. Stay away from the area until local authorities say it is safe, because tsunami is not a single wave but a series of waves that can vary in size.
3. Do not go to the shoreline to watch for a tsunami. When you can see the wave, it is too late to escape.

6.3 What to do after a Tsunami

1. Avoid flooded and damaged areas until the affected area is declared safe by the government officials.
2. Help injured or trapped persons. Help neighbours, infants, elderly people where necessary.
3. Stay away from debris in the water; it may pose a safety hazard to boats and people.
4. Look for poisonous snakes and insects in water, in buildings, roads and fields.
5. Don't use tap water till officials have checked it and found it safe for drinking.

7) CONCLUSION AND RECOMMENDATIONS

1) The coastal region of Pakistan are susceptible to earthquake generated Tsunamis.
2) Due to high risk of loss of human life in Makran Coast a warning system be established for guarding Makran coast including Gawadar Port.
3) Warning system for area surrounded by Murray Ridge (Located 100 – 150 Km southwest of Karachi) must be installed at the earliest.
4) The dissemination of information to the residents (areas of concern) through Radio, TV, mosque etc must be scientifically arranged and planned.
5) Arrangements for post and during disaster relief measures be taken through Government agencies, NGOS, Hilal-e-Ahmer. A master plan be prepared which includes identification of sites for evacuated people. Arrangement for transporting from effected areas with list of hospitals, Civil Defence offices and other civic agencies be prepared.
6) Disaster Management Board be established by the Government of Pakistan involving all the stake holders.

List of Earthquakes Originating in Sindh/Baluchistan/North Arabian Sea Between the 1905 to 2004

S. No.	Date	Lat	Long	Mag	Intsity At EC	Remarks
1	29/9/1930	26.8	66.5	6	8	
2	27/8/1931	26.8	67.3	7.4	10	Felt at Karachi
3	18/4/1932	25	64	6	8	
4	7/7/33	24	65	6	8	
5	19/4/1934	24	65	5.2	7	
6	15/5/1935	28	68	6.2	8	
7	31/10/1940	24.5	70.3	5	7	
8	3/7/42	27	66.5	5.1	7	
9	6/2/43	24.5	63	6.3	9	Felt at Karachi
10	27/11/1945	24.5	63	8	11	Felt at Karachi
11	5/8/47	25.5	63	7.3	10	Felt at Karachi
12	6/2/53	25.1	66.3	6	7	Felt at Karachi
13	27/7/1953	26.5	65	5.1	7	
14	21/7/1956	23	70	7	9	Felt at Karachi
15	27/12/1962	24.7	65.2	5	8	Felt at Karachi
16	29/12/1963	23.9	65.2	5.9	8	Felt at Karachi
17	12/8/63	25.3	62.7	5.2	7	
18	18/11/1963	24.7	67.7	4.5	5	Felt at Karachi
19	24/3/1965	24.8	67.7	4.5	5	
20	26/3/1965	25.2	67.7	4.8	6	
21	26/3/1965	24.2	69.6	4.6	6	
22	23/7 /1965	26.2	65.1	4.7	6	
23	13/11/1965	26.2	65.1	4.7	6	
24	27/5/1966	24.6	68.5	4.9	6	
25	12/11/66	25.8	68	5.1	7	
26	11/9/67	27.5	66	4.6	6	
27	1/1/68	24.6	66	5	7	Felt at Karachi
28	13/6/1968	24.6	66.4	4.7	6	
29	23/5/1969	24.5	68.8	4.4	6	
30	3/12/69	24.9	65.6	4.7	6	
31	3/2/70	24.4	68.6	5.2	7	
32	3/8/70	25.2	62.9	4.7	6	
33	9/11/70	23.8	64.7	5.1	7	
34	14/5/1971	25.2	68	4.4	6	Felt at Karachi
35	28/1/1972	26.6	66.3	5.9	7	Felt at Karachi
36	23/9/1972	25.4	66.8	4.9	6	Felt at Karachi
37	24/3/1973	26.7	66.4	4.5	6	
38	25/5/1973	25.5	66.3	4.8	6	
39	5/6/73	25.1	66.8	4.8	6	
40	14/8/1973	25.4	65.6	4.9	7	
41	2/9/73	24.9	63.2	5.2	7	
42	27/10/1973	24.6	62.2	4.7	6	
43	29/3/1974	26.8	66.5	4.6	6	
44	4/10/74	26.4	66.7	5.7	8	Felt at Karachi
45	24/12/1974	25.6	64.8	4.6	6	
46	23/2/1975	26.5	67	4.5	6	
47	6/6/75	25.5	66.7	4.1	5	

S. No.	Date	Lat	Long	Mag	Intsity at EC	Remarks
48	3/2/7 6	25.2	63.5	4.7	6	
49	3/3/76	25	70.4	5	7	
50	4/6/76	24.5	68.5	5.1	7	
51	12/9/76	24.6	65.7	5.6	7	
52	29/5/1977	23.5	64.6	4.9	6	
53	29/5/1977	23.6	64.9	5	6	
54	26/5/1977	25.4	68.2	4.5	6	
55	10/2/78	25.3	62.4	5.1	7	
56	24/5/1978	23.8	65.5	5.1	7	
57	27/5/1978	24	66.2	4.4	6	
58	12/8/79	24.4	64.9	4.6	6	
59	26/2/1981	26.3	67.6	4.7	6	
60	26/4/1981	24.1	69.5	4.1	5	
61	31/1/1982	24.1	69.6	4.8	6	
62	18/4/1983	27.8	62.1	6.4	8	
63	2/9/84	26.8	66.2	5.3	7	
64	2/9/84	26.9	66.5	4.7	6	
65	17/12/1985	24.5	67.5	5.4	7	Felt at Karachi
66	19/12/1985	24.2	67.8	4.8	6	Felt at Karachi
67	18/5/1988	25	63.5	4	5	
68	30/1/1992	25	63	5.5	7	
69	11/11/96	25	66.7	4	5	
70	20/12/1996	25	66.6	4	5	
71	9/1 0/97	25	66.3	3.3	4	
72	17/3/1998	25	66.5	4.1	5	
73	18/8/1998	25	66.7	4	5	
74	16/8/1999	26	67.3	4.7	6	
75	26/01/2001	23.4	70.2	7.0	9.0	

RECONSTRUCTION CHALLENGES AFTER KASHMIR-HAZARA EARTHQUAKE

By

Professor M. Ilyas*, and M. Rizwan**

ABSTRACT

The Kashmir-Hazara earthquake, which is found as the biggest natural disaster, ever afflicted Pakistan. The earthquake occurred on 8th October, 2005, measured 7.6 on the Richter scale and its epicenter has been located near Muzaffarabad. The earthquake affected areas of Abbottabad, Mansehra, Balakot, Ghari Habibullah, Muzaffarabad, Bagh, Battagram, Battal, Allai, Naran valley, Neelum valley and Jhelum valley. The earthquake caused more then 80,000 fatalities and some 200,000 people were injured. The affected areas mostly comprise of hilly terrain and numerous efforts are going in during the recovery phase. During recovery phase the issues such as temporary shelters, construction activity in rural areas, problems in construction of new houses in urban areas, relocation issues of affected areas and type of construction to be adopted for future require special emphasis. This study addresses all these issues in the light of observation made during the visit of areas affected by Kashmir-Hazara Earthquake and provides conclusions that will assist the people involved during the recovery phase.

1) INTRODUCTION

The northern areas of Pakistan contains number of tectonic features and most of them are active [REF 1]. The Kashmir-Hazara earthquake, which occurred as result of rupture along Muzaffarabad fault, has been recognized as the largest natural calamity ever occurred in known history of Pakistan. The earthquake occurred on 8th October, 2005, measured 7.6 on the Richter scale and its epicenter was located near Muzaffarabad. The affects of the earthquake were distressing enough to influence the complete nation. The regions which were mainly affected by the earthquake includes the areas of Abbottabad, Mansehra, Balakot, Gharihabibullah, Muzaffarabad, Bagh, Battagram, Battal, Allai, Naran valley, Neelum valley and Jhelum valley. In the earthquake over 80,000 people were killed, 200,000 were injured and more then 4 million left homeless. The United Nations soon after the earthquake warned Pakistan about the disaster with in the disaster if the quake victims were not ministered properly. According to an assessment of World Food Programme (WHF) 2.3 million people require supply of food to survive through winter and UNICEF has warned about the danger of losing 10,000 children because of hunger, winter and diseases. According to an official estimate about 140,000 people, out of the total earthquake survivals, are located above snow line and many of them are still waiting for shelter. Although the recovery efforts are continuing in affected areas but these are facing challenge of harsh weather and tough mountainous terrain. Thus the affects of the earthquake have prolonged much long after its actual time history. The Peak Ground Acceleration (PGA) of the earthquake as recorded in Islamabad and Abbottabad is given in Tables 1 and 2 and the total devastation caused by the earthquake is given in Table 3 below.

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Table 1

Components of Peak Ground Acceleration (PGA) of main shock of Kashmir-Hazara earthquake recorded in Islamabad

S/No	Component	PGA (g)
1	East-West	0.02289
2	North-South	0.026016
3	Vertical	0.029984

Table 2

Components of Peak Ground Acceleration (PGA) of main shock of Kashmir-Hazara earthquake recorded in Abbottabad

S/No	Component	PGA (g)
1	East-West	0.231
2	North-South	0.19679
3	Vertical	0.08677

Table 3

Estimated devastation caused by Kashmir-Hazara earthquake

Location	Area Km^2	Population	Deaths	Affected
Balakot	2025	228,051	20000	200,000
Muzaffarabad	6117	745,755	39400	574,852
Bagh	1368	393,415	15000	292,927
Rawalakot	855	411,034	2700	120,558

After the earthquake the government of Pakistan formulated its approach towards the recovery process, while at the same time private sector began articulating their own vision of recovery. In order to organize the efforts of government and private sector Earthquake Reconstruction and Rehabilitation Authority (ERRA) has been created. During the initial recovery phase rescue of alive, treatment of injured, burial of the dead, debris removal of the urban areas and provision of food and tents as immediate shelter has been carried out. Now, after the initial phase the reconstruction phase, including rebuilding of housing and infrastructure, is in hand. This reconstruction will not be easy and because of tough terrain and harsh weather this will be the one of the most difficult post earthquake construction ever carried out. There are some important issues like temporary shelters, construction activity in rural areas, problems in construction of new houses in urban areas, relocation issues of affected areas and type of construction to be adopted for future that require special emphasis. In this study these issues are addressed in the light of observations made during the visit of affected areas.

2) Temporary Shelters

Many individuals, firms and NGOs have come up with different ideas and some have implemented them by donating some houses or offering their assistance to government and those who are interested to spend on the relief of the effected. But the important issue regarding the maximum cost and life of the short term shelters has not been argued. Also, government has not earmark any areas where permanent construction is difficult at this point of time or will be time consuming. However, use of material like tin sheets, cement, fiber glass and bamboos can be used for the purpose. Some short conferences or seminars can be arranged to discuss the use of these materials, transportation to the affected areas, erection methods and cost. It should be decided, at government level, whether to educate the local manpower and provide material or provide fabricated houses that can be assembled on site. In both cases government and NGOs should organize some training classes or workshops quickly. The amount and method of disbursement of funds can be planned accordingly depending on the type of temporary shelters selected. The local population should be involved in discussion with the engineers and government official to decide about the layout of the temporary shelter. Use of salvage material, involvement of the local population in construction and designing shelters that can be converted to permanent structure should prove to be most economical and effective solution.

3) Construction Activity in Rural Areas

The type of construction that was adopted in the rural areas before the earthquake mostly consisted of single storey timber frame, both braced and unbraced, structures with dry stone masonry infill. These structures demonstrated poor seismic performance and require reconsideration. The braces, if at all are provided; consist of timber logs with cross sectional dimensions varying from 152.4 x 152.4 mm to 203.2 x 203.2 mm [2]. The infill dry stone masonry walls are mud plastered in order to achieve smooth finish. The wooden frames consist of timber columns of size 200 x 250 mm to 250 x 300 mm supporting beams, known as main beams, of same size at the top. The main beams support load bearing beams, known as cross beams, which are 4.25 m in length with same cross sectional dimensions as of columns. The spacing between the cross beams varies from 0.9 to 1.6 m. The cross beams are simply placed on the main beams or at times are joined together by means of nails or nailing a wooden cross piece on the side of the beams across the interface. But these connections are not effective enough to transfer the moments and clearly violate seismic codes [REF 3].

After the earthquake the inhabitants of the affected area were afraid to occupy these houses. This is the most obvious response of any community effected by the earthquake [REF 4]. Thus an immediate need of huge quantity of tents was felt. Now the problem in reconstruction of the rural areas is to decide whether to continue the use of the traditionally constructed houses or not. If government decides to continue the use of such construction then modifications must be suggested to improve its seismic performance. However, a decision to discontinue will require a reasonable alternative that can be adopted easily by the inhabitants. The interviews of the inhabitants of the effected areas reveal that if the traditional construction is continued with modification it will get popular quickly and adopted easily. Different Universities can be tasked to identify safe and economical construction and asked to give out at least one workable solution in the form of a prototype structure.

The terrain of the affected areas is mountainous and not easy to access, therefore, engineers and workmen should be trained by the universities to supervise and construct the approved pattern of new construction and retrofitting existing structures. These teams can be hired by the government on contractual basis and located at some suitable village, which can be accessed by inhabitants of other villages. At the deputed location the trained engineers and workmanship can construct model houses and conduct training workshops, NGOs can also be involved in this process. The estimated expenditure on construction can be divided into installments and paid to the owners as the construction work progresses. All the newly constructed and the retrofitted structures should be documented properly and certified by the engineer in-charge for their correctness. However, construction of villages by tendering and hiring contractors is also workable but it may cost more then the owner driven construction of the individual houses because of involvement of the intermediaries. The efforts of different NGOs working in the effected areas should be organized. Areas can be distributed to different NGOs and given options either to work in collaboration with the government or independently. The NGOs, which choose to work independently can be assigned to construct number of houses, depending on their capability, under the supervision of the government hired engineers and supervisors. The NGOs, which select to work in collaboration of the government, can bear 50% of the expenditure of construction of houses in their area, according to their potential.

4) Problems in Construction of New Houses in Urban Areas

In urban areas an overall development plan should be formulated before setting in the actual reconstruction. The development plan should include the details of reconstruction,

rehabilitation techniques and layout of the houses. In normal post earthquake scenario the new construction has been found easier for the government to ensure compliance with mandatory earthquake resistant features [REF 5]. For new construction issues like location, land ownership, type of construction, minimum covered areas and debris removal will require special emphasis. The need here will be to quickly provide the technical knowledge and funds for construction. The economic status and size of the family are two basic factors that can be to decide about the size of construction. The construction can be divided into three categories (1) small single bed room houses (2) large single bed room house and (3) Two bedroom houses. These basic units should be extendable horizontally by the owners. For urban areas the disbursement of the installments of the fund can be done through the bank, thus this will make the process of funds utilization more efficient and unambiguous. The involvement of the owners will assist in effectively deciding about the issues like size of rooms, location of kitchen and washrooms. The owners can be asked to keep themselves involved in the construction process to ensure the quality control. Government can organize a team of engineers for overall supervision, which can visit the construction sites for quality control and correct utilization of the funds. Different houses existing at same location can be grouped together and given to one contractor through tender. In such type of construction quality control and adherence to mandatory earthquake-resistance technology can be easy. Payments to the contractor can be made through the owner or government may pay directly to the contractor. In urban areas only those NGOs should be allowed to involve in the construction of new houses which have previous experience of construction.

In the urban areas the construction or rehabilitation of infrastructure is also required. In the mountainous terrain the major towns are the life line of the small villages, thus the reconstruction of the rural areas will be greatly affected by infrastructure available in the base towns. During the interviews at Muzaffarabad it was told by the inhabitants that the water supply, electricity and food supply were not available for the initial four days. The sewerage of Muzaffarabad city was also affected during the ground shaking. Government owned buildings, especially schools, suffered from major damage in the earthquake. Road infrastructure was also damaged by the earthquake to an extent that relief operation was hampered either due to land slides or road blockage due to relief conveys. On 12th of October, 2005 a 20 Km long traffic blockage occurred on Mansehra-Balakot road due to conveys of relief goods. Major efforts are required to reconstruct the government owned buildings and reestablish the city centers. For government management to work properly its infrastructure should be established at priority. Schools and hospitals are necessary for the social rehabilitation of the earthquake victims. The reconstruction development plan should include establishment of water points, ration stores and hospitals to work in emergency. The points vulnerable to land slides, due to ground shaking and rains should be earmarked and earth moving machinery can be placed near such points.

5) Relocation Issues of Affected Areas

Many of the villages have suffered heavy damage either due to failure of the underlying soil or their proximity to the fault. Therefore, some of these may require relocation before carrying out post earthquake construction. The relocation of villages will require decisions regarding ownership of the land held before the earthquake and the land allotted in the new location. The land allotment in the new location should be based on the pre-earthquake land ownership i.e. owners with larger tracts of land before the earthquake should get more land. If less land is available at the new location then land distribution can be based on ratio proportion. The selection of the new location must be based on the consensus of the inhabitants or the influential people of the villages can be convinced regarding the new location. When the inhabitants do not reach the consensus for relocation, which is otherwise deemed necessary by the experts, training workshops can be arranged to increase the awareness.

In Balakot and Muzaffarabad huge destruction have occurred due to failure of the underlying soil; therefore, proper soil investigation is required before deciding about the reconstruction at the same location or construction at new location. The affects of relocation of towns or portion of towns on the surrounding population must be studied before relocating. Decision regarding placement of city center so as to include courts, mandi and city hospitals should be critically weighed before finalizing. Though relocation offers good advantages of proper town planning, modern infrastructure facilities and ensures earthquake-resistant construction to entire satisfaction but it has disadvantages such as cost and complete dislocation from familiar to unfamiliar environments.

6) Type of construction to be adopted for Future

It is wisely said that we cannot eliminate the earthquakes but we can mitigate their affects. The type of construction for future should be subjected to research. After witnessing the devastation of the Kashmir-Hazara earthquake the lessons learnt should be taken as the guide line. The threat perception of all the faults existing in Pakistan must be carried out and maximum possible ground acceleration, at different locations, should be estimated. Structures which can resist the estimated ground acceleration should be designed and their damage evaluated accordingly. However, some structures which have been used in different regions of the worlds in post earthquake construction are given in table 4 below.

Table 4
Proposed structures used in different post-earthquake construction

Load Bearing Members	**Roof**
Masonry walls with bands	RCC Slab
RC frame with infills	RCC Slab or Corrugated galvanized iron (CGI) on timber truss
RC walls	RCC Slab

7) Conclusions

From the study conducted, the main observations made and conclusions drawn are summarized as:

1. Temporary shelter which can be transformed into permanent structure will be most economical and effective.
2. The tough terrain and harsh weather is hampering the relief operation, therefore, use of local material during reconstruction phase will be very helpful.
3. To reduce the social problems and to ensure the satisfaction of the inhabitants they must be involved in the decision process.
4. Awareness of the inhabitants about the earthquake resistant structures should be increased through training workshops.
5. To avoid repetition of efforts, the contribution of private sector and the NGOs should be properly organized and streamlined.
6. Conferences, seminars and training workshop should be planned to train the masons and engineers regarding earthquake resistant structures.
7. The problems identified during the Kashmir-Hazara earthquake should be subjected to research in the Universities for solution.

8) Acknowledgement

The authors acknowledges enabling role of Higher Education Commission Islamabad, Pakistan and appreciates its financial support through "Merit Scholarship for Ph.D Studies in Science and Technology (200 Scholarships)". The authors are also thankful to University of Engineering and Technology, Lahore, Pakistan for its support.

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THE ENVIRONMENTAL MANAGEMENT (EM) BENEFITS TO PAK INDUSTRIES

By

Zeeshan Nawaz[1], Kashif Sagheer[2] and Usman Ali Naeem[3]

ABSTRACT

This study utilized questionnaires to investigate the status of environmental management (EM) in Pakistan Industrial Sector, specifically the ISO approved industries. This study probed the question; "How do different industry characteristics and different extents of engagement in environmental management activities affect the financial investment in and benefits derived from environmental management?" Factor analysis of variables (ANOVA), and description statistics were the tools used in analysis. These tests concerning environmental management budgeting and investment indicated that over the next five years industries' financial backing for environmental management activities will be negatively affected by the extent of activities they are currently performing. In addition, in the future manufacturers will place an increasing emphasis on environmental management by investing greater capital and adopting more and more environmental management skills. Results revealed that currently, even by exercising environmental management industries do not achieve commensurate financial benefits. This study maintains that this phenomenon is due to the fact that Pak industrialists continue to adopt a passive attitude towards environmental management promotion as the amount of investment is still insufficient. The history of this aspect of management is still too short; and firms are still not capable of effective application of environmental management.

1. INTRODUCTION

Environmental protection is of the utmost importance in the 21st century and for a management based on environmental consensus has already become a prerequisite for any industry wishing to survive long term in today's highly competitive business environment. Effective EM activities should be an indispensable part of any firm's effort to tackle the dual challenge of economic growth and proper environmental protection. However, at present there are still many industries that look at EM as a burden possessing the potential to diminish corporate profit while offering no concrete benefits that would stimulate increased profits. The amount of capital and resources spent on EM cannot, in the short run, produce an obvious revenue benefit; therefore firms come to look on EM as an encumbrance. However, there is now much evidence that EM application can save resources, reduce waste, open up vast business opportunities and thus produce greater profits. The benefits of EM include increase in sales volume, decreased cost, greater competitiveness and improved corporate image [14]. Executing EM activities can, in addition to helping an industry achieve higher profits, save on capital, increase efficiency, broaden market share, improve corporate reputation/image and enable proper adherence to laws and regulations, thus avoiding penalty/fines, etc [11]. Therefore corporations that hope to achieve long lasting success should look to EM for long-term benefits. Industries that have implemented EM believe firmly in its usefulness, while industries that have yet to engage in EM regard it with fear and dubiousness. This stark contrast in attitudes prompted this study of the benefits of investment in EM. The objectives of this study were as follows:

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(1) To investigate the status of Taiwan manufacturers' current EM efforts.

(2) To analyze the factors that influence EM involvement and investment.

(3) To analyze the extent of benefits that firms have derived form EM.

1.1 The Environmental Management (EM)

EM can be defined as the effort to minimize the negative effects of products on the environment [8]. EM as the management of the negative effects of products and processes on living and non-living beings and on cultural systems [16]. EM is the organizing of industry resources, viewed from the standpoint of product life, to minimize the negative effect of corporate activities have on the environment [1].

1.2 The Benefits of Environmental Management (EM)

In addition to benefiting the environment, EM brings many tangible and intangible benefits to industries themselves. Table 1 describes the benefits that industries can expect to gain from implementation of EM, as interpreted by domestic and international scholars [17, 13, 11, 15, 5].

Table 1: EM Benefits for Industries in Light of International Scholars

Sr. No.	EM Benefits	Sally [13]	Ku [9]	Lu [11]	Yang [17]	Wen [15]
1.	Sales Volume Increase		*			
2.	Order Increase		*			
3.	Profit Increase	*		*		
4.	Production Cost Reduction	*		*	*	
5.	Production Capacity Increase	*		*		
6.	Product Reliability Increase	*		*		
7.	Company Reputation/Image Improvement	*		*	*	*
8.	Market Share Increase			*		*
9.	Customer Confidence in Product Increase	*	*			*
10.	Customer Complaint/Claim Reduction		*			*
11.	Better Company-Public Interaction				*	*
12.	Product Competitiveness Increase	*		*		

2. THE INVESTMENT IN ENVIRONMENTAL MANAGEMENT

Industry faces more stringent environmental protection demands, their decisions regarding investment in EM are growing tougher and more complex [5]. The decision concerning investment in environmental protection is influenced by a number of factors:

(1) Laws, rules and regulations;

(2) The stance of regulatory agencies (EPA, Ministry of Environment, Renewable Energy Resources Board, etc.);

(3) The clout of environmental protection, political and social action groups;

(4) The focus of the media; e.g. national, regional or local protests;

(5) The status of competitition; e.g. the stance of competitor manufacturers and the attitude of customers;

(6) The status of Pak industrial development; e.g. the effects of environmental protection measures;

(7) The ability of corporations to adjust to environmental protection policies;

(8) The ability of corporations to integrate manufacturing technologies;

(9) The ability of the executors of EP to accommodate specialized knowledge;

(10) The size of the predicted return on the industrial investment.

3. RESEARCH METHODS

The basic framework employed in this study is described in Fig. 1. This study investigated how differences in industry characteristics and degrees of advancement in the implementation of EM affect a manufacturer's extent of involvement in and benefit derived from EM.

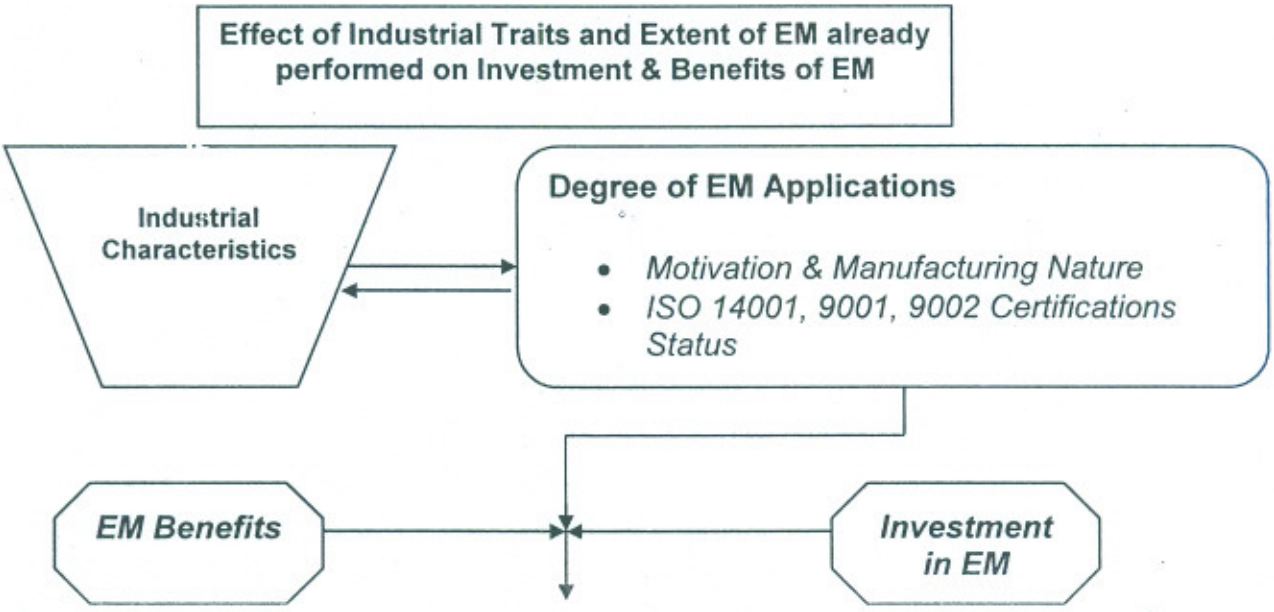


Figure 1: Research Framework

3.1 VALIDATION OF THE MODEL

This study investigates how differences in industry characteristics and differences in the extent to which EM has been promoted affect corporate EM budgeting and the benefits derived from EM. The testing model was established by investigating the literature review [15, 13, 7, 3] concerning investment in environmental protection, EM and the benefits of EM activities in Pakistan.

Model Z: Differences in industry characteristics and the degree of EM promotion activities performed affected manufacturers' budgeting for EM. The testing model established is shown below:

$$EMI: = f(IC, EMD, X)$$

EMI= Manufacturer's involvement in EM.

IC= Industry characteristics ~ including whether stocks were listed or over-the-counter and differences in the field of manufacturing specialization, capital, and the average amount of sales profit over the last three years.

EMD= The extent of advancement of EM activities, i.e., whether or not ISO 14000 certification has been obtained, the number of years under certification, whether or not the employees responsible for EM are full or part time, the number of staff devoted to EM and the salary of the EM staff.

X= Other factors

Thus Mode Z describes how the manufacturer's choice of degree of involvement in EM is affected by industry characteristic differences, differences in the extent of EM activities performed and other factors.

Model K: Model K was established to show the benefits of executing EM as based on Model Z.

$$EME = g\,(EMI,\ Y) = (IC,\ EMD,\ X,\ Y)$$

EME: The benefit to manufacturers of implementing EM.

EMI: The extent of involvement in EM. This study investigates the influence industry characteristics and the degree of EM performed has on the benefits derived from EM.

Y: Other factors

Therefore Model K describes how the current level of involvement in EM and other factors influences the degree of benefit manufacturers derive from implementing EM. By inserting the factors from Model Z into Model K, we can see that industry characteristics, the extent of current involvement in EM and other factors affect EM benefits.

3.2 THE RESEARCH HYPOTHESIS

Using the model established, this study subjected four categories of hypotheses to testing.

Hypothesis A

Differences in the extent of involvement in EM do not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis A-1: Whether or not ISO 14001 certification has been obtained does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis A-2: The number of years under ISO 14001 certification does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis A-3: Differences in the levels of EM tasks performed do not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis A-4: The number of staff devoted to EM activities does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis A-5: The salary of staff devoted to EM activities does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis B

Different industry characteristics do not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis B-1: Industry characteristics do not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis B-2: Amount of capital does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis B-3: Sales amount over the last three years does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis B-4: Whether stocks were listed or over-the-counter does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis C

Differences in the extent of involvement in EM do not influence the amount of benefits manufacturers derive from EM.

Hypothesis C-1: Whether or not ISO 14001 certification has been obtained does not influence manufacturers' benefits derived from EM.

Hypothesis C-2: The number of years under ISO 14001 certification does not influence manufacturers' benefits derived from EM.

Hypothesis C-3: Differences in the levels of EM activities performed do not influence manufacturers' benefits derived from EM.

Hypothesis C-4: The number of staff devoted to EM activities does not influence manufacturers' benefits derived from EM.

Hypothesis C-5: The salary of the staff devoted to EM activities does not influence manufacturers' EM budgeting and financial investment in EM.

Hypothesis C-6: The amount of involvement in EM does not influence manufacturers' benefits derived from EM.

Hypothesis D

Industry Characteristics do not influence the benefits manufacturers derive from EM

Hypothesis D-1: Industry characteristics do not influence manufacturers' benefits derived from EM.

Hypothesis D-2: The size of capital does not influence manufacturer's benefits derived from EM.

Hypothesis D-3: Average total sales over the last three years do not influence manufacturers' benefits derived from EM.

Hypothesis D-4: Whether stocks are listed or over-the-counter does not influence manufacturers' benefits derived from EM.

Table 2: The test results matched up with the proposed hypothesis.

Hypothesis Number	Hypothesis Content		Test Results
B-1	Industry characteristics (the fact that they are from different industries) do not influence the benefits they derive from EM.		Confirmed
B-2	Manufacturers' amount of capital does not influence their budgeting and financial investment in EM		Confirmed
B-3	Manufacturers' average amount of sales profit does not influence their budgeting and financial investment in EM.		Confirmed
B-4	Whether manufacturers' stocks are listed or over-the-counter does not influence their budgeting and financial investment in EM		Confirmed
A-1	Whether or not manufacturers have obtained ISO 14001 certification does not influence their budgeting and financial investment in EM.	2002	Confirmed
		Next 5 Years	Rejected
A-2	The number of years manufacturers have been under ISO 14001 certification does not influence their budgeting and financial investment in EM	2002	Confirmed
		Next 5 Years	Rejected
A-3	The fact that manufacturers are engaged in different levels of EM activities does not influence their budgeting and financial investment in EM.		Confirmed
A-4	The number of employees manufacturers devote to EM does not influence their budgeting and financial investment in EM		Rejected
A-5	The salary of manufacturers' employees devoted to EM does not influence their budgeting and financial investment in EM		Rejected
D-1	Manufacturers' industry characteristics (the fact that they are from different industries) do not influence the amount of benefits they derive from EM	Production Benefit	Confirmed
		Sales Benefit	Rejected
		Impage/Compe-titiveness Benefit	Confirmed
D-2	Manufacturers' amount of capital does not influence the amount of benefits they derive from EM.		Confirmed
D-3	Manufacturers' average sales profit over the last three years doe not influence the amount of benefits they derive from EM.		Confirmed
D-4	Whether or not manufacturers' stocks are listed or over-the-counter does not influence the amount of benefits they derive from EM.	Production Benefit	Confirmed
		Sales Benefit	Rejected
		Impage/Compe-titiveness Benefit	Confirmed
C-1	Where or not manufacturers have obtained ISO 14001 certification does not influence the amount of benefits they derive from EM.		
C-2	The number of year's manufacturers has been under ISO 14001 certification does not influence the amount of benefits they derive from EM.	Production Benefit	Rejected
		Sales Benefit	Confirmed
		Impage/Compe-titiveness Benefit	Confirmed
C-3	The fact that manufacturers are engaged in different levels of EM does not influence the amount of benefits they derive from EM.		Confirmed

3.3 THE QUESTIONNAIRE DESIGN

This study questionnaire comprised three parts:

- The type of industry engaged in, amount of capital, the average sales over the last three years, and whether stocks were listed or over-the-counter.
- The extent to which the manufacturer pursued EM. The questions in this section described the firm's current status of EM activity promotion; i.e. the division in charge of EM, the number of staff in the division and their salaries, the principal duties.
- How budgeting and financial support for EM, what degree of financial backing is provided, etc. The questions in this section elucidated the influence manufacturers' execution of EM activities had on benefits.

The operational effectiveness measurement index, a Likert 5-point scale was utilized. A value of "5" indicated a high level of effectiveness, "3" indicated no change, and "1" indicated a decrease in effectiveness. The measurement standard is described below in Table 3.

Table 3: Measurement Standard

Marked-5	Moderate-4	No Difference-3	Moderate Lack-2	Marked Lack-1
Influence >10%	Influence of 5~10%	Influence (or Lack of) < 5%	Lack of Influence > 5~10%	Lack of Influence > 10%

3.4 THE QUESTIONNAIRE DATA ANALYSIS

To evaluate the open questionnaire data, this study used a SPSS software package to perform statistical analysis consisting of the following:

1. **Description Statistics:** This study used description statistics to determine frequency of occurrence and derive the sample distribution.

2. **Factor Analysis:** The weight of each factor corresponding to each index item represented the degree of correspondence between the index item and the factor [7, 17]. Three common factors emerged that accounted for 68.2% of total variance.

- The "Production Benefit" factor, which was related to 5 index items: "Profit Increase," "Production Cost Reduction," "Production Capacity Increase," "Product Reliability Increase," and "Customer Complaint/ Claim Reduction".
- "Sales Benefit," accounted for 12.7% of the variance and was related to 3 index factors: "Sales Volume Increase," "Order Increase," "Market Share Increase."
- "Image/Competitiveness Benefit" accounted for 11.2% of the variance and was related to 4 index items: "Company Reputation/Image Improvement," "Customer Confidence in Product Increase," "Better Company Public Interaction," and "Product Competitiveness Increase".

3. **One Factor Analysis of Variance:** This study used one factor analysis of variance (ANOVA) to ascertain whether the effects of factors exhibited significant difference.

Thus, in this study; factor analysis was used to distill the original 12 items to three common factors, thus making it possible to more systematically comprehend EM benefit factors.

3.5 THE TREND ANALYSIS

There are two primary motivations for executing EM: external and internal. External forces may demand that a company adopt EM; for example, a firm may turn to EM to adhere to a law or regulation, to obtain ISO 14001 certification [17] or in order to keep up with industrial development trends. On the other hand, the decision to engage in EM may come from within the firm, either because the firm recognizes its responsibility for protecting the natural world or because it wishes to reduce cost. Here we can see the attitude of companies towards the promotion of EM is no longer a matter of simply engineers passively coerced by the government or by the trends of the time, but has become a self-motivated activity. This change of attitude indicates that companies are gradually coming to recognize the importance of EM [3]. According to manufacturers, the greatest benefit EM offers is in terms of heightened company reputation and image. Less marked benefits were seen in the areas of cost reduction, interaction between company and the public, increase in consumer confidence in the product, and increase in competitiveness.

4. CONCLUSION

The results concerning the effect of characteristics of different industries and financial support for the manufacturer's involvement in EM indicate these two factors do not influence each other. Perhaps a salient degree of correspondence did not emerge because all types of manufacturers are now involved in EM promotion activities [7]. The questionnaire results indicated that the probable factors accounting for a manufacturer's extent of financial backing for EM include the degree of importance placed on EM, laws, and the scope of impact production has on the environment. Factors such as the amount of capital and sales and whether the firms' stocks were listed or over-the-counter seemed to have a negligible effect on EM budgeting.

In examining the test results concerning the relationship between the manufacturer's degree of involvement in EM and the amount of financial support allotted for EM, we found that the financial backing designated for EM over the next few years was deeply affected by the extent of EM activities currently being carried out [10]. It seems that in future, manufacturers will place greater emphasis on EM and will be willing to invest a large amount of capital in EM promotion activities.

Test results concerning the relationship between industry characteristics and the benefit of implementing EM indicated that only one item - "Sales Benefit" - was affected by the firm's field of specialization [13]. "Production Benefits" and "Image/Competitiveness Benefit" were not seriously affected. These results indicate that manufacturers those adopted EM have already exhibited improvement in terms of "Sales Benefit," i.e. total sales, order quantity, and market share.

Test results concerning the relationship between the manufacturer's degree of investment in EM and the benefit of EM exhibited correspondence between the following two factors:

- Manufacturer's "Production Benefit" factor vs. the number of years since the manufacturer had obtained ISO 14001 certification.
- The "Image/Competitiveness Benefit" factor vs. the financial investment in EM over the next five years.

Probable reasons for this include the following: the attitude of company head towards EM promotion activities was passive, the investment in EM promotion activities was insufficient, the history of EM promotion activities was short, consumers did not place sufficient

importance on green products and green consumption, and manufacturers did not effectively promote EM activities. As long as these outdated attitudes and situations remain in place, manufacturers will not be able to reap the full benefits of EM.

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MANAGING SALINE WATER FOR INCREASED CROP PRODUCTIVITY - A CASE STUDY

By

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ABSTRACT

Supplemental irrigation has become a prerequisite to minimize risks of crop failures in both rainfed and irrigated agricultural areas, and usually, surface irrigation, in which the entire or most crop area is flooded, is used for irrigating these croplands. More often, however, the water management skills on the farm are lacking and water supplies may be uncertain, and so irrigation efficiency tends to be low. The amounts of water used for irrigation are usually large, and small gains in irrigation efficiency would produce significant increases in water saving. Increased irrigation efficiency also decreases the energy costs of pumping and providing water for irrigation. Several areas of the Indus Basin, Pakistan are susceptible to non-point source groundwater contamination from crop production under current conjunctive water application. The sustainability of groundwater resource is under threat especially in shallow fresh groundwater aquifers, inland as well as at the coastal regions. Efficient use, and economical reuse, of water in irrigation is the key to protecting the quality and quantity of such shallow groundwater aquifers. Generally, these aquifers have limited potential for extracting large quantities of groundwater, and small discharges cannot be applied to the fields using surface irrigation methods. Therefore the effectiveness of alternative (such as pressurized irrigation systems) irrigation methods needs to be determined. In the proposed 'Intermittent Irrigation' practice, the integration of surface irrigation and sprinkler irrigation is suggested in such a way that could help in controlling salinity in the root zone with minimum application of irrigation water by improving the leaching efficiency. The evaluation of this practice was made at the farmers' fields and by using SWAP model, which is a one-dimensional model to describe transient water flow and solute transport in a heterogeneous soil root system. The model offers a wide range of possibilities to address practical questions in the field of agriculture, water management and environmental protection.

1) INTRODUCTION

In the Indus Basin, the natural groundwater is deep and saline because of the marine origin of the hydro-geologic formation. Percolation of irrigation and rainfall waters has formed fresh groundwater lenses in many locations above the underlying saline groundwater. The thickness of this fresh groundwater lens varies from a few meters to more than 150 m. In general the fresh groundwater lenses are found close to the rivers, and saline groundwater areas are present in the central and lower regions of the *doabs* –area enclosed between two rivers (Figure 1). In fresh groundwater areas, the fresh groundwater lenses are thick (> 38 m). In saline groundwater areas, the thickness of fresh groundwater lenses is thin (< 38 m). According to Zuberi and McWhorter (1973), saline groundwater areas occupy more than 30 percent of the Indus Basin, mainly in Punjab and Sindh. In saline groundwater areas of the Indus Basin, about 200 Billion Cubic Meters (BCM) of fresh groundwater has accumulated (NESPAK, 1983), and over 20 BCM of fresh groundwater is being recharged annually to these saline groundwater areas (Sufi et al. 1998). Development of appropriate technology and adequate operational strategies for the safe abstraction of this valuable resource can contribute significantly in overcoming the scarcity of water in the Indus Basin (Saeed et al.

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2003). The use of 'skimming wells' can be an effective way of extracting fresh groundwater from thin lenses without disturbing the underlaying saline groundwater layers (Sufi, 1999). A skimming well is a multi strainer tubewell penetrating partially, but vertically using small bores, into the unconfined aquifer underlain by saline groundwater layer.

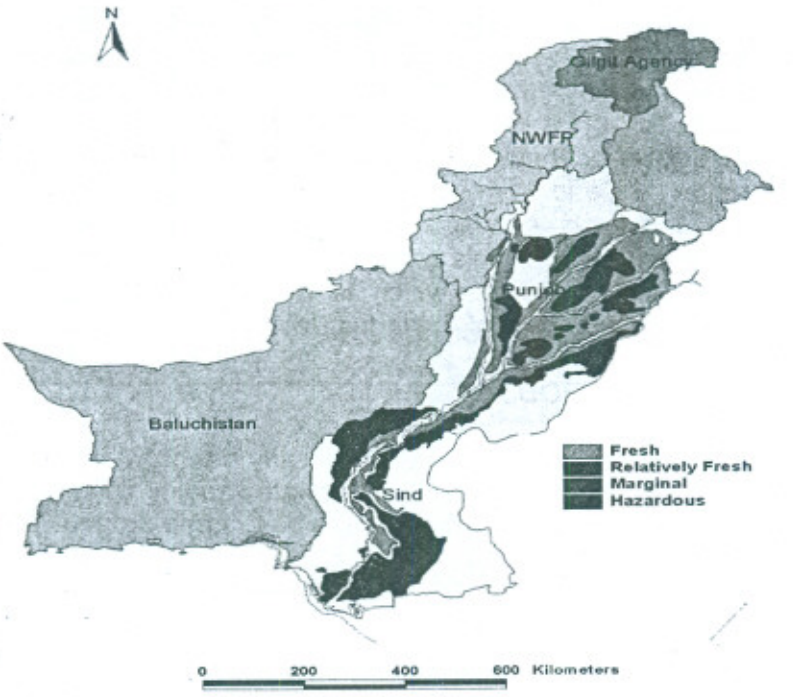


Figure 1 - Spatial distribution of composite groundwater quality (0-107 m depth) in the Indus Basin of Pakistan. Three classes of groundwater quality were defined for this analysis. The first class having quality of less than 1.5 dS/m represent the relatively fresh groundwater zone, whereas the next class having quality ranging between 1.5-4.0 dS/m represent the marginal groundwater zone. The quality class of more than 4.0 dS/m represents the hazardous groundwater zone.

The large-scale groundwater exploitation from the Indus Basin aquifer started about 40 years ago when about 1400 deep single-strainer tubewells with 30-75 m depth and discharge capacity of 80 l/s were constructed to combat waterlogging and salinity problems. Since then the utilization of groundwater for irrigation has grown rapidly. Farmers locally developed this technology as a single-strainer shallow tubewells in fresh groundwater areas, and small bore multi-strainer shallow tubewells, referred to as skimming wells, in saline groundwater areas of Punjab and Sindh provinces (Hafeez et al. 1986). The current rates of groundwater use in most of the areas are unsustainable. Rapidly falling water tables and increasing salinity of the pumped groundwater attest that more expensive and poor quality groundwater will have to be used for irrigation in future. This impairs the capacity of this region to feed its growing population.

In saline groundwater areas of Punjab and Sindh provinces, farmers have installed almost 10,000 skimming wells (ACE Halcrow JV Consultants, 2002). Most of these wells are not properly designed and are run with inadequate operational schedules (Saeed et al. 2002). As a result, saline groundwater upconing, i.e. upward movement of saline groundwater in an unconfined aquifer having fresh groundwater lens underlain by saline groundwater layer, occurs and the quality of pumped water is deteriorating and a large number of wells have already been abandoned. Moreover farmers do not have sufficient knowledge on the use of skimmed groundwater for maximizing crop yields and minimizing environmental degradation.

Thus, salinity problems are emerging in large areas and salt-affected soils are becoming an important ecological problem with about 6 million ha already affected.

Due to relatively low discharge rates (3-8 l/s) the skimmed groundwater cannot be applied to the fields using surface irrigation methods. Therefore the effectiveness of alternative irrigation methods, such as pressurised irrigation systems, needs to be determined. Application of small volumes of water might trigger the salinity development in these soils due to less leaching of salts. Therefore long term effects of the skimmed groundwater use on crops and soils also need to be evaluated. This paper presents the results of a three year study conducted to develop cost-effective and technically feasible design and operational strategies of skimming wells and to prepare guidelines for managing root zone salinity in areas where skimmed groundwater was used with pressurised irrigation, either alone or intermittently with surface irrigation. This study was conducted in the *Chaj Doab,* the area between Jhelum and Chenab Rivers, which is one of the intensively developed and significantly productive irrigated areas of the Indus Basin.

2) MATERIALS AND METHODS

A GIS-based spatial analysis was carried out to classify deep groundwater quality zones in the study area. The marginal or hazardous groundwater quality zones, which cover around fifteen villages in the study area, were anticipated to have fresh groundwater lenses resulting from deep percolation of irrigation and rainfall waters. From these identified villages, six different sites (two in SCARP-II saline zone, and four in SCARP-II non-saline zone) were selected to carry out the Diagnostic Analysis (DA). The DA used resistivity survey, bore logs (to a depth of 75m), water quality sampling from hand pumps, and shallow wells to investigate salinity and hydro-geological conditions of the aquifer. These investigations confirm the presence of fresh groundwater lenses overlying the saline groundwater and in estimating the thicknesses of these fresh groundwater lenses, groundwater quality at different aquifer depths, and the aquifer composition.

A farmer owned sixteen-strainer skimming well was monitored from June 2000 till December 2001 to study its hydraulic performance and hydro-salinity behaviours under different pumping regimes. In this well, each strainer had 6.7m of screen length, and well penetration ratio was estimated to be equal to 60% of the fresh groundwater lens. The horizontal distance of strainers from suction point varies from 1.5 to 4.6m. For 74% of the times of observed tubewell operations, this well was operated between 2-8 h/d. The MODFLOW and MT3D models (Chiang and Kinzelbach, 1996) were calibrated for the Chaj doab conditions (Asghar et al. 2002) and used to study the effect of different penetration depths, operational hours and discharge rates on the quality of pumped groundwater.

For MODFLOW simulations, a spatial domain 89m x 89m was divided into 23 rows and 23 columns, with each cell of 3.9x3.9m. The vertical domain of 100m was divided into nine layers of variable thickness to accommodate groundwater quality profile, and to allow for simulation of the different well penetration ratios. No flow boundary condition was considered on the sides and the bottom boundaries. The top layer was considered unconfined while other layers were considered convertible between unconfined and confined depending upon the aquifer hydraulic conditions. The multi-strainer skimming well was represented as a single well point in the centre of the simulation network. The values of horizontal hydraulic conductivity, vertical hydraulic conductivity, and specific yield of the aquifer were taken as 30 m/day, 20 m/day, and 0.4 (-), respectively. For the MT3D, the best-fitted values of the longitudinal, horizontal transverse, and vertical transverse dispersivity were taken as 1.89, 0.378, 0.378m, respectively. The value of the effective porosity of the aquifer was set equal to 0.4 (Kemper *et al.*,1976). The initial depth to water table was taken as 1.5m. The initial thickness of fresh groundwater lens was 30m for relatively thick lenses, and 20m for thin lenses.

The operational strategies and resulting quality of skimmed groundwater optimized by MODFLOW simulations were tested for their long-term effects on crops and soil degradations. Soil-Water-Atmosphere-Plant relationship (SWAP) model (van Dam et al. 1997) calibrated by Sarwar et al. (2000) was used for this purpose. SWAP is a one-dimensional model to describe transient water flow and solute transport in a heterogeneous soil root system, which can be under the influence of groundwater. Root water extraction at various depths in the root zone is calculated from potential transpiration, root length density and reduction due to water and/or salinity stress in the root zone. Irrigation applications can be prescribed at fixed intervals or user may choose various irrigation timings, depth and water quality. The details of input parameters used for model simulations are given in Table 1. Long-term simulations were performed for a period of 15 years, as daily rainfall, maximum & minimum temperatures, sunshine hours and wind speed were available from the study area.

Table 1 - Parameters used to describe crops and soil hydraulic properties in SWAP model.

Crop parameters	Wheat	Maize	
Boesten parameter, β (cm1/2)	0.63	0.63	
Kc values for full crop cover	1.15	1.15	
Maximum rooting depth (cm)	110	100	
Limiting pressure heads (cm)	h1= -0.1; h2 = -1.0; h3 = -500; h3' = -900; h4 = -16,000	h1= -30; h2 = -30; h3 = -325; h3' = -600; h4 = -8,000	
Van Genuchten-Mualem parameters	Soil layer 1	Soil layer 2	Soil layer 3
Depth of layer (cm)	0-30	30-280	>280
Soil texture	Loam	Silt loam	Loamy sand
Residual moisture content, (θres)	0.000	0.000	0.028
Saturated moisture content (θsat)	0.384	0.509	0.400
Saturated hydraulic conductivity, (Ksat) (cm/d)	60	40	72
Shape parameter, α (cm-1)	0.0085	0.0090	0.0140
Shape parameter, n (-)	1.350	1.450	2.663
Shape parameter, λ (-)	1.0	1.0	0.5

A farmer's field measuring 0.4 ha was extensively monitored from July 2002 to April 2003 to gather information regarding irrigation applications, sowing and harvesting dates, groundwater pumpage and other agronomic parameters needed for model application. Maize-wheat cropping pattern was used for simulation, as these are the dominant crops of the study area. Maize is usually sown during the months of July-August to meet the fodder demands for their animals, while wheat is sown during October-November after the maize harvest. The groundwater table, which fluctuated in the range of 1.5 to 4.0m, was used as bottom boundary condition. The upper boundary condition was dependent on daily evapotranspiration rate, actual rainfall, and irrigation. In SWAP, the soil profile was taken as 480 cm and was divided into three soil layers for model application. The soil hydraulic properties of these three layers were defined by Van Genuchten and Mualem (VGM) parameters, and were adapted from Sarwar et al. (2000).

3) RESULTS AND DISCUSSION

3.1 Design and operational strategies of farmers' skimming wells

The results of Participatory Rural Appraisal (PRA) and field surveys conducted in the study area revealed that the major factors contributing to the popularity of skimming wells among farming community include: (i) availability of locally manufactured material, (ii) availability of

local expertise for drilling, installation and maintenance, (iii) shallower depths to water table that helps using centrifugal pumping units, (iv) technically simple as compared to other groundwater extractions technologies, and (v) economics and affordability. The deterioration of water quality and reduction in well discharges over time were identified as major problems. Due to absence of any design code in the area, every skimming well in the area was different than the others in term of depth of skimming wells, number of strainers and horizontal distance of strainer from suction point. The depth of skimming well in the area ranges between 9 to 27 m and the number of strainers varying from 2 to 26.

The results of modeling simulations revealed that initially discharge rate increased considerably with the increase in number of strainers. However, after 6 strainers the increase in the discharge rate was marginal. This shows that farmers could reduce number of strainers to a maximum of 4-6 without reducing the discharges. This will not only reduce the initial installation costs but will have a significant impact on the operational costs. The horizontal distance of strainers from suction point was found to be between 1.5 to 4.5 m (as shown in Figure 2). The common perception of farmers and well drillers in the area was that well discharge increases with the number of strainers. It was also believed that putting all strainers at equal distance from suction point would reduce the well discharges. Therefore most of the skimming wells in the area are installed on the recommendations of local drillers rather than suitability of hydro-geological conditions.

3.2 Evaluating the performance of farmers' skimming wells

The calibrated MODFLOW model was then used to study the effect of different discharge rates, daily operational hours and operational strategies on quality of pumped groundwater. The simulations were performed for the aquifers having thin layers (< 38 m) of fresh groundwater underlain by saline groundwater. The simulations were performed for one year using calibrated MODFLOW model. The pump was operated for two hours after every week. Weekly irrigation schedule was preferred to comply with the 7-day fixed rotational canal water distribution system called 'warabandi'. This system is widely practiced in the study area to ensure equitable distribution of scarce canal water supplies to all farmers located in a specific canal command area. This system allows each farmer to take an entire flow of the watercourse once in seven days and for a period proportional to the size of his land holding. As water duty is insufficient, groundwater is usually pumped to supplement canal water supplies.

Based on the results of MODFLOW simulations, two operational strategies were considered safe for skimming wells in this area as given in Table 2. In the first strategy the maximum irrigation application depth will be 15 mm while for the second strategy, it can increase to 30 mm. The average irrigation depth applied by farmers using surface irrigation method is about 40 mm. Therefore when skimmed groundwater will be used in isolation for irrigation, surface flooding method will not be suitable therefore pressurised irrigation systems should be preferred. For this study, a raingun system was used for irrigation with the skimming wells. However when skimmed water is used in conjunction with the canal water, surface irrigation methods can also be used for irrigating field crops.

Table 2 - Operational strategies for sustaining fresh groundwater resources.

Parameters	Strategy I	Strategy II
Discharge rate (l/s)	8	8
Daily operating hours (h/d)	2	4
Operational schedule (d)	7	14
Depth of irrigation (mm)	15	30

3.3 Evaluating the long-term effects of skimmed groundwater use on crops and environment

The interactions of irrigation (skimmed groundwater and canal water) with crop production and soil salinity were studied under actual field conditions. Five irrigations were applied to a maize crop, out of which three irrigations were from canal water using basin irrigation system, and two irrigations were applied through raingun sprinkler system using skimmed groundwater. Wheat received a total of six irrigations: three irrigations from canal water, and three irrigations using skimmed groundwater. During these irrigations to maize and wheat crops, the average depth of canal water applied was around 40 mm; whereas an average depth of skimmed groundwater applied using raingun sprinkler system was 15 mm. The salinity of canal water and skimmed groundwater used for irrigations was around 0.3 and 1.3 dS/m, respectively. Irrigation schedules for wheat and maize together with the source of irrigation water followed by farmers and used for SWAP simulations are given in Table 3.

A set of simulations was carried out to evaluate the consequences of farmers' current irrigation practices on crops and soil salinity. The EC_e values represents the average root zone salinity calculated over a 1.0 m deep root zone. The root zone salinity during the maize season remained below 2.0 dS/m. This can be attributed to sufficient leaching during this period due to excessive monsoon rains. The relative transpiration (ratio of actual transpiration over potential transpiration: Ta/Tp) for maize was 0.96, which means that crop did not suffer from water or salt stress. However, this was not the case for the subsequent wheat crop where soil salinity remained below 2.0 dS/m for initial and middle stages of the crop but markedly increased to 6.0 dS/m in the late growing stage. This shows that the water applied through irrigation and rainfall to wheat was not enough to provide adequate leaching of salts from the root zone. As plants are constrained in their capacity to extract water from roots under highly saline conditions, the relative transpiration of wheat was reduced to 0.88 (12% yield reduction as compared to potential). This suggests that for sustainable crop production in these areas, farmers need to calculate their irrigation and leaching requirements more carefully.

Table 3 - Farmers' current irrigation practices used for SWAP simulations

Crop	Sowing Date	Date	Irrigation Depth (mm)	Source of water
Maize	August 23, 2002	Aug 18, 2002*	36.21	Canal water
		Sep 11, 2002	38.62	Canal water
		Sep 25, 2002	34.76	Canal water
		Sep 30, 2002	8.54	Skimmed water
		Oct 01, 2002	10.67	Skimmed water
		Oct 03, 2002	33.80	Canal water
Wheat	October 18, 2002	Oct 03, 2002*	36.21	Canal water
		Nov 07, 2002	41.04	Canal water
		Nov 20, 2002	8.54	Skimmed water
		Nov 28, 2002	6.40	Skimmed water
		Dec 12, 2002	37.18	Canal water
		Feb 25, 2003	12.81	Skimmed water

Figure 3 shows the long-term effects of farmers' current irrigation practices on crops and soils. The results indicate that continuation of farmers' current irrigation practices could lead to serious land degradation and crop growth problems due to salinity build up particularly in below average rainfall years. Therefore farmers need to adjust their irrigation schedules every year on the basis of crop evapotranspitaions, precipitation and salinity situations of the

soil profile. This is essential to sustain crop production in these areas where canal water supplies are not sufficient and availability of fresh groundwater is very limited.

A second set of simulations with the calibrated SWAP was carried out to evaluate the long-term effects of two operational strategies optimized by using MODFLOW (Table 2) on crop production and development of soil salinity. The modeling results reveal that the deviations in annual precipitations from an average year are critical to maintain equilibrium between different water and salt balance components. Figure 4 indicates the impacts of long-term use of skimmed groundwater through pressurized sprinkler system on crops and soil salinity. The results suggest that farmers could keep the salinity levels in the root zone below 4 dS/m if they apply 15 mm of sprinkler irrigation after every week to maize and wheat. The ratio of Ta/Tp based on 15 years average for this scenario was estimated to be 0.82 for maize and 0.96 for wheat. The reduction in maize yield was higher than wheat because maize starts facing salinity stress around 2 dS/m whereas wheat can tolerate salinity levels up to 6 dS/m.

Similar results were obtained for strategy II. This strategy also allows farmers to irrigate their fields using surface irrigation methods. Both of these scenarios showed good response to relatively dry years. The slight build up in salinity during dry years was compensated in the subsequent average and above average rainfall years. Therefore on long-term basis, crop production will be sustained due to availability of acceptable quality of groundwater for irrigation. In the areas where periodic water shortages are experienced and access to groundwater is also limited as in the case of major parts of the Indus basin, the decision of which irrigation strategy to choose should not be a question of which schedule will maximize the crop production, but rather of which one will optimize crop production in a sustainable way within the available water supply and management capacity. The simulation results clearly indicate that in the present water deficient environment of the Indus basin, farmers need to do precise calculations of their irrigation and leaching requirements to halt environmental degradation and foster crop production.

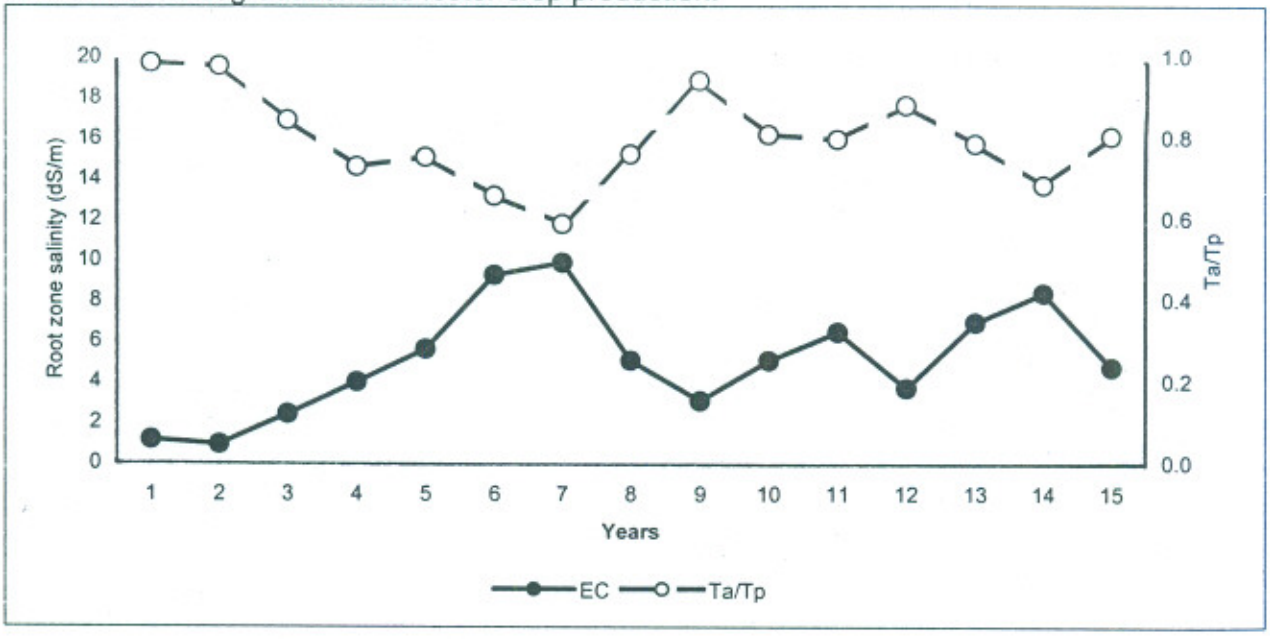


Figure 3 - Temporal development of relative transpiration and average root zone salinity in the top 1.0 m of the soil profile as influenced by farmers current irrigation practices for maize and wheat crops

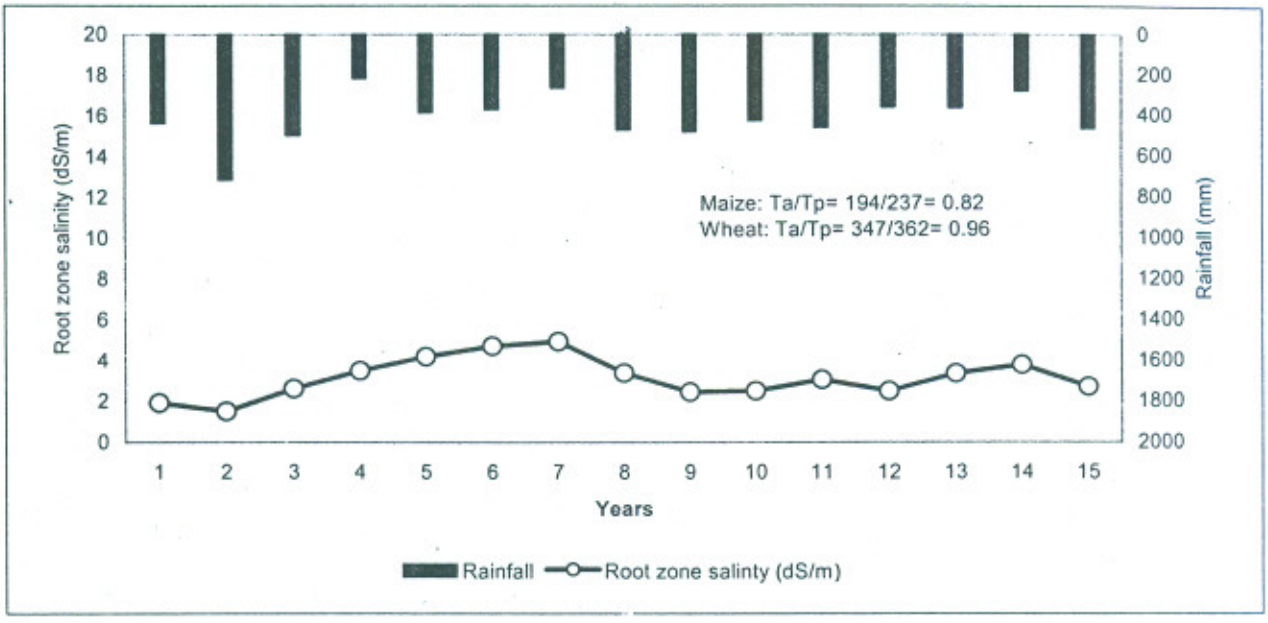


Figure 4 - Temporal development of average root zone salinity in the top 1.0 m of the soil profile using raingun sprinkler system following strategy I (Discharge = 8 l/s, Daily operation hours = 2 and operational schedule = weekly).

4) CONCLUSIONS

- The farmer's present practices regarding design, operation and use of skimmed groundwater are not consistent with the hydro-geological conditions prevailing in the study area. The continuation of these practices could lead to serious land and aquifer degradation problems that can threaten the long-term sustainability of irrigated agriculture in this area.

- Skimming wells should mainly be used for supplemented irrigation rather than full-scale irrigation with surface irrigation methods. Due to low discharges of skimming wells, pressurized irrigation methods are preferred for irrigating field crops with the skimmed water.

- To sustain crop production, reduce soil salinity hazard and prevent aquifer degradation, well discharge of 8 l/s with 2 hours per day operation after every week will be the best management strategy for this area. By adopting this strategy long-term availability of groundwater of acceptable quality can be ensured, which is an essential element for sustaining crop production. Weekly operational schedule of skimming wells is in concurrence with the existing 7 days canal water distribution cycle therefore it will be much more practical for farmers. This schedule can maintain near optimal crop yields without compromising on environmental sustainability.

- Farmers need to adopt better management strategies for the use of available water resources (quantity and quality) to overcome problems of land degradation and consequent crop yield reductions. Relevant extension agencies should play a more active role in educating farmers by introducing the research results to the farming communities.

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