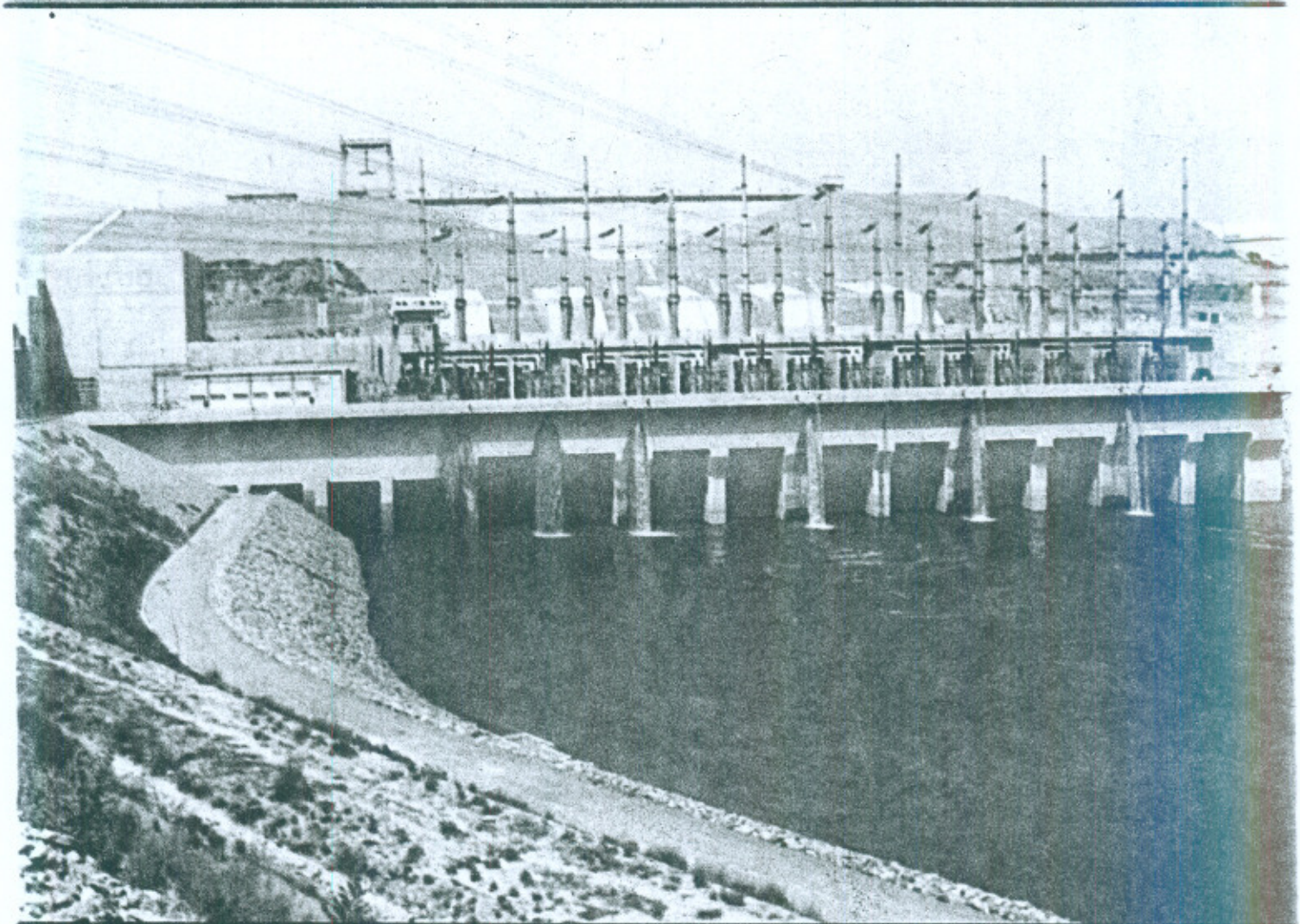
Engineering News

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Vol: 42 January - March 2005 No: 4



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Ghazi Barotha Power Complex

47th YEAR OF PUBLICATION

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ON OTHER PAGES

IN THIS ISSUE

EDITORIAL

☆ Water for Life 3

NEWS

☆ PEC Delegation Visit 4
☆ Press Release by NESPAK & NDC 4-5
☆ Welcome to New Members 5

TECHNICAL VIEWS

☆ Depletion of Ozone Layer in the Stratosphere 6
- *Prof. Dr. Javed A. Aziz, Prof Shaukat Hayat*

☆ Evaluation of Adequacy and Performance of Drainage Inlets of Surface Drains 10
- *Muhammad Muneeb Khan, Dr. Ata-ur-Rehamn Tariq*

☆ Social Impact Assesment of Subsurface Drainage 21
- *Aftab H. Azahr, M. Rafiq, M. M. Alam*

☆ Production of Spheroidal Graphite Cast Iron (S.G. Iron) for an Automobile Brake Drum 30
- *Dr. M. Taqi Zahid Butt, Salman Aziz*

☆ Effect of Fiber Content on the Mechanical Properties of Glass Fiber-Phenolic Matrix Composite 33
- *Dr. A. Ahmad, S. Akhtar, M. Yousaf*

☆ Reclamation of Irrigated Agriculture Through Pipe Drainage - Cropping Intensity Analyses 40
- *Aftab H Azhar, M. M. Alam, M. Rafiq*

☆ Surface Hardening of Mild Steel by Pack Chromizing 49
- *M. Ashraf, M. A. Raza, A. Salam, J. Ahmad*

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WATER FOR LIFE

"World Water Day" celebrated every year on 22nd March to highlight water related issues. This year (2005) was no exception. However, current President of Pakistan Engineering Congress while welcoming the participants to a seminar, pointedly agitated the most relevant factors requiring stake holder's attention, particularly the Government. Some of those are :

- Per capita availability of water is reducing.
- Storage and regulation is required to optimize use.
- Water supply for drinking and sanitation is not satisfactory.
- Integrated water resources management is required for cost effective and environmentally sustainable manner.
- Aggravating water (shortage) situation warrants highest priority for building new dams to avoid fast approaching water crisis.

These are the hard facts which have not attracted the national approach mainly due to lack of proper discussion forums. The technical issues have been allowed to wander in the political jungles. Discussions taking place in water-tight compartments without permitting the adequate amount of oxygen. The oxygen in this case is the scientific data and engineering information. What is most astonishing is the scantiness of information from water resources centres of excellence, the water research council and the engineering universities. The Congress itself has no mechanism to reach out the members for advice and consensus building for arriving at conclusions on national issues.

It is imperative for the Government of Pakistan to control population increase, adopt water economy measures by popularizing drip irrigation, green house farming, metering water consumption and very importantly forcing water-related institutions to publish their works for the benefit of all and sundry in particular for planners and the managers. Conservation, in future is the only hope in preserving water for life and sustainability of its supply in all respects. We will, however, fail to appreciate Government of Pakistan's efforts in regulating the services like telephone, electricity and electronic media.

Regulation of providing important services is essential for confidence building for investment by the private sector. The fairer the regulatory laws the higher will be the confidence level. Government has recently appointed a supra-regulatory committee to look into the issues and problems across the whole range of regulatory regime. One area that needs immediate attention is that of water sector where no protection is available to consumers, farming and drinking both in terms of adequacy of quality, pressure, timings and continuity. The suppliers should be bound by legal contracts to meet a range of standards. We suggest that water sector must be regulated, as well, by an autonomous and neutral water regulatory authority in each province encrusted with introduction of legal contracts, monitoring the quality (independent of suppliers), approving water rates and adjudicating the water disputes.

News

Pakistan Engineering Congress delegation visits additional overhead bridge at Jhal Khanuana, Faisalabad city including service road.

A Delegation of Pakistan Engineering Congress consisting of senior engineers paid a technical visit to the project on 30th March, 2005.

Introduction

The existing Jhal Khanuana Bridge connecting the Jhal Khanuana Chowk with GTS Chowk through the two-lane, two-way flyover was one of the busiest and most congested transportation, facilities in Faisalabad. The GTS Chowk serves as a focal point for traffic to and from the Railway Station, Nagina Cinema, Ghanta Ghar, Rail Bazar etc., as well as government offices/colonies. The Jhal Khanuana Chowk serves as a focal point for traffic to and from the People's Colony, Samundari Road, Abdullah Pur, Satiana Road etc. Due to the heavy traffic demand on this flyover, traffic jams and long queues develop during peak hours.

The additional overhead bridge, 10m wide, is, being constructed adjacent to the existing bridge. The additional bridge/flyover has two lanes, so that the traffic coming from GTS Chowk to Jhal Khanuana will utilize this new one-way bridge/flyover, while the traffic coming from Jhal Khanuana to GTS Chowk will utilize the existing bridge/flyover (which will now be made one-way). All types of light and heavy traffic, except the bicycles and animal-drawn vehicles, will be allowed to use the two bridges/flyovers. A service road, 7.3m wide, is also being constructed along additional bridge from GTS Chowk to Jhal Khanuana Chowk.

Dual Carriageway, each carriageway 11.1m wide, along Surwala Minor runs from Railway Station to Faisalabad-Jhang Road and works as approach to Airport, Carriageway from Railway Station to Faisalabad-Jhang Road is being overlaid as it was already functional and in good condition. For the other carriageway, from Faisalabad-Jhang Road to Railway Station, existing surface is being reworked and prepared as subgrade and pavement structure is being provided on top of that.

Major objectives of the project are to:

- Remove traffic congestion and delays and improve level of service.
- Ensure uninterrupted flow of traffic from Jhal Khanuana to GTS Chowk and save fuel and maintenance costs due to idle running.
- Ensure efficient and speedy movement of freight and passengers within the city by removing traffic constraints to boost up the industrial development potential.
- Improve the environment due to the reduction of smoke and exhaust emitted by idling vehicles.

Salient Features:

- Date of Commencement : 20.08.2004
- Expected Date of Completion : 30.06.2005
- Cost of Project : Rs. 204.366 Million
- Length of Bridge : 707 m
- Length of Service Road : 691 m
- Length of Dual Carriageway : 2.88 km

Project awarded to NESPAK

Economic Cooperation Organization (ECO), based in Tehran (Iran), has signed an agreement with NESPAK Joint Venture of Consultants for carrying out a detailed "Feasibility Study Report on Interconnection of Power Systems of all the ten ECO countries" to identify a system configuration enabling secure, stable and reliable exchange of bulk amount of power amongst the member countries for economic and optimal utilization of their power resources. The Islamic Development Bank will provide finances for this study.

Other two members of the Joint Venture are WAPDA and ECO Consultancy and Engineering Company (ECO-CEC).

The agreement was signed in Tehran on March 29th, 2005 between Mr. Askhat Orazbay, Secrtetary General of ECO and Mr. Mushtaq Ahmad Bhatti, Vice President of NESPAK on behalf of the Consultants Joint Venture.

The Feasibility Report, among other things, will also make an assessment of the current and projected situation of ECO Power Systems and identify technically feasible interconnection options for required facilities such as transmission lines, sub-stations, telecommunication, system control and data acquisition (SCADA).

The NESPAK – led Joint Venture has won this project after an international competition. The detailed Feasibility Report will be prepared in 20 months period.

The ECO members countries are Pakistan, Iran, Turkey, Afghanistan, Kyrgyzstan, Tajikistan, Kazakhstan, Turkmenistan and Azarbaijan.

Project awarded to NDC

The Small Dams Organization of NWFP Government has awarded a consultancy services contract to a consortium, led by National Development Consultants (NDC), for preparing the detailed design and provide construction supervision of four small dams in different parts of the province.

These earthfill dams are Maroobi Dam in Peshawar District ; Jabba Khattak Dam in Nowshera District ; Khair Bara Dam in Haripur District and Barganato Dam in Bannu District.

An agreement for these Projects was signed in Peshawar last week by Mr. Raqib Khan, Director General of Small Dams Organization on behalf of NWFP Government and by Mr. M. A. H. Enver, Partner of National Development Consultants; Mr. Abdul Ali Khan, managing Partner of BAK Consulting Engineers and Mr. Sajjad Khan, Managing Director of Electra Consultants.

All these Dams, which will have spillways, outlet works and irrigation system, are a part of development activities of the Provincial Government. These Dams will bring under-cultivation thousands of acres of barren land in their respective areas and bring happiness and prosperity to the local population.

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 15-01-2005

1 Engr. Ashfaque Ahmad
2 Engr. Tariq Saleem Chaudhry
3 Engr. Ammar Saeed
4 Engr. Abdul Aziz Soomro
5 Engr. Muhammad Saqalain
6 Engr. Ghulam Yaseen
7 Engr. Lt. Col. Arshad Nasim Qureshi

Members admitted on 26-03-2005

1 Engr. Mohsin Nazir
2 Engr. Amir Ahmad Afzal
3 Engr. Haji Muhammad Hassnain
4 Engr. Muhammad Yaqoob
5 Engr. Shakeel Ahmad Kashmiri
6 Engr. Haroon Mukhtar
7 Engr. Muhammad Hafeez Anwar
8 Engr. Shazil Waqar
9 Engr. Javed Iqbal
10 Engr. Zulqurnain Abbas
11 Engr. Hafiz Sohail Hasan Aslam
12 Engr. Muhammad Waseem
13 Engr. Sheraz Habib
14 Engr. Parkash
15 Engr. Danish Andrew Gill

DEPLETION OF OZONE LAYER IN THE STRATOSPHERE

By

Prof. Dr. Javed A. Aziz[1] and Prof. Shaukat Hayat[2]

1. INTRODUCTION

Ozone is a minor and naturally produced component in the stratosphere which encircles the earth some 15 to 45 Km above its surface. It is not an abundant chemical in the atmosphere but it is highly significant due to its property of shielding the earth from much of the potentially damaging ultraviolet radiation coming from the sun. Should ozone disappear, the earth would become uninhabitable for most forms of life. Due to this property, ozone depletion in the stratosphere is now recognized as a major environmental problem with potentially catastrophic effects.

Approximately 90% of ozone is found in the stratosphere where its peak concentrations are about 300 ppb. The altitude of peak concentrations varies from about 25 Km near the equator to approximately 15 Km in the polar region (Botkin and Keller, 1995).

Ozone concentration is measured in Dobson Units (D.U.) One D.U. is equivalent to a concentration of 1 ppb of ozone. If brought to normal pressure at sea level, all of the existing atmospheric ozone would form a band of no more than 3 mm thick around the earth. (Kemp. 1994). Concentrations of ozone in the stratosphere have been measured for more than 70 years.

Today there is nearly a 30-years record of ozone concentrations available from more than 30 locations around the world. It was found that in the Antarctic zone, the ozone concentrations, taken each year in October, decreased from 300 D.U. in 1970 to 200 D.U. in 1984 and a low of about 90 D.U. in 1993. The records indicate that the ozone concentrations in the stratosphere have been decreasing since mid 1960s. (Botkin and Keller, 1995). The concentration of ozone in Polar Regions is more than that near equator. In fact much of ozone is produced near the equator but moves from equator towards poles with global circulation patterns which are not well understood.

2. CHEMISTRY OF OZONE FORMATION

Ultraviolet (UV) radiations from the sun constitute about 10% of the total sunlight reaching the earth (Money, 1994). UV radiations range in wavelength from 0.1μm to 0.4 μn. These are further sub-divided into UV-A, UV-B and UV-C. UV-C has the shortest wavelength (0.1 - 0.28 μm) and is lethal to living things. Due to very high energy, UV-C are able to break down molecular oxygen in the stratosphere to atomic oxygen. (Enger and Smith, 2004).

$$O_2 \xrightarrow{UV-C} O+O$$

Each of the oxygen atoms then combines with an oxygen molecule to create ozone.

$$O+O_2 \xrightarrow{UV-C} O_3$$

Due to the above reactions, UV-C are almost totally screened out (absorbed in the stratosphere) and none reaches the surface of the earth.

---

[1] Professor of Civil Engineering, B.Z.U., Multan.
[2] Institute of Environmental Engineering and Research, University of Engineering and Technology, Lahore.

It is UV-B with wave length 0.28 to 0.32 μm which draws most of the attention relative to the ozone problem. UV-B radiation damages the living cells. Fortunately UV-B is strongly absorbed by stratospheric ozone. As O_3 absorbs UV-B radiations, it breaks down again ozone to molecular oxygen and atomic oxygen.

$$O_3 \xrightarrow{UV-B} O_2 + O$$

Natural conditions prevailing in the atmosphere result in a dynamic balance between creation and destruction of ozone. The quantities of ozone involved are interesting. A total of about 350,000 metric tonnes of ozone are formed and destroyed daily (Manahan, 1994). In the process most of the ultraviolet radiations (all UV – C and between 70 - 90% UV - B) are absorbed in the ozone layer. (Botkin and Keller, 1995). Close to equator ozone allows only 30% of UV-B radiation to reach the earth surface (Kemp. 1994). UV-A radiations have the longest wave length (0.32 - 0.4 μm) and can cause some damage to living cells. It is not affected by stratospheric ozone and is transmitted to the earth surface.

3. SIGNIFICANCE OF OZONE LAYER

In the absence or thinning of stratospheric ozone shield, high intensities of ultraviolet radiations from the sun may make the planet earth uninhabitable. UV-B radiations damage biological molecules, amino acids, proteins, nucleic acid and consequently cells and tissues. The affected cells are therefore at risk from scrambling of their genetic code. UV-B radiations also inhibit photosynthesis and damages plant tissues thus affecting adversely the growth rates of plants and resulting in low yield of crops (Kemp. 1994).

The destruction of microscopic plants (phytoplankton) by UV-radiations may also severely reduce the productivity of the world's seas and damage the earth food chain. As plankton in the sea are a sink for carbon dioxide, their disruption by UV radiation might increase CO_2 levels in the atmosphere causing global warming.

Exposure to high levels of UV light causes sun burns, accelerate aging of skin, suppress the immune response and long exposures to bright sunlight increase the incidence of skin cancer and cataract in humans. Thinning of ozone layer in the stratosphere is therefore causing great concern as the cases of cataract and skin cancer are soaring in Argentina, Chile, Australia, New Zealand and South Africa (Miller, 1994). Fortunately indigenous people of these countries have dark skin which contains melanin to filter out UV-B radiations. Thus people with light complexion are more susceptible to skin cancer (Manahan, 1994). In Australia, skin cancer is ten times more prevalent than in north Europe (Kemp. 1994). According to the United States National Academy of Sciences, an ozone reduction of as little as 3% would lead to as many as 20,000 additional cases of skin cancer in the U.S. alone.

Stratospheric ozone plays a key role in climatic processes through its capacity to absorb UV radiation. This warms the stratosphere and maintains a steep inversion of temperature between 15 to 50 Km above the earth surface. A decrease in ozone layer would therefore result in cooling of the stratosphere which may ultimately lead to a net effect in cooling of the earth surface (Kemp. 1994).

4. THINNING OF OZONE LAYER

Globally, stratospheric ozone is declining at a rate of about 3 percent per decade (Brown et al., 1996). The thinning of stratospheric ozone layer was first identified over the Antarctic in 1984 (Middleton, 1996). The reduction of ozone levels in Antarctica has been described popularly as 'ozone hole'. The term, in fact, is a misnomer and applies to a reduction of thickness in ozone layer of more than 50%.

The phenomenon is manifested by the appearance, during the Antarctic late winter and early spring, of severely depleted stratospheric ozone (from 15 to 70%) over the pole region.

This depletion lasts for about 30 - 40 days annually between September and November, when circumpolar vortex, a mass of cold air, circulates around the southern pole region and isolates it from the warm air in the rest of the world. The cold air causes clouds to form in the stratosphere. These clouds contain ice crystals to which chlorine adheres and attacks ozone. When the circumpolar vortex breaks up, the ozone depleted air spreads northward diluting ozone levels in South America, New Zealand and Australia (Raven et al., 1993).

Atmospheric circulation around Arctic and other aspects of its meteorology are much more complex than that in Antarctica. Because of this condition ozone depletions are considered less likely to occur in the northern hemisphere. Nevertheless, a central depletion of ozone in Arctic was also noted in 1989 (Cornwell, 1993). In 1995, ozone losses of more than 10 percent were observed over northern middle latitude in the spring reaching an unprecedented 35 percent over Siberia (Brown et al., 1996).

5. CAUSES OF OZONE DEPLETION

The major culprit in ozone depletion consists of a group of commercially important compounds called. chlorofluorocarbons (CFCs). These are used as propellant in aerosol cans, as coolant in air conditioners and refrigerators (e.g. Freon) and in foam for insulation and packing (e.g. Styrofoam) and as solvents. CFCs are chemically stable in troposphere, insoluble in water and persist for over 100 years in the atmosphere. Annually about 0.9 million metric tonnes of CFCs are emitted into the atmosphere (Botkin and Keller, 1995). The two CFCs of most concern are CFC-11 ($CFCl_3$) and CFC-12 (CF_2C1_2). Other ozone eater chemicals include halons (bromide containing compounds), methyl bromide (a pesticide), carbon tetrachloride (a solvent) and methylchloroform (clothes cleaning solvent).

Spray cans, leaky refrigerators and air conditioners and production and burning of plastic foam products release CFCs into the atmosphere. In stratosphere UV radiations break them to chlorine, fluorine and carbon (Raven et al., 1993). Chlorine atoms go through chain reaction with ozone and convert it into oxygen. (Enger and Smith, 2004).

$$Cl + O_3 \rightarrow C1O + O_2$$
$$ClO + O_3 \rightarrow C1 + 2O_2$$

One chlorine atom can destroy several thousand molecules of ozone.

As CFCs have a lifetime of 75 to 140 years, even if their production is completely banned today, those already in the atmosphere will continue causing ozone depletion and a maximum is expected to occur between 2000 and 2020 (Botkin and Keller, 1995).

In addition to CFCs, oxides of nitrogen also destroy ozone. Nitric oxide (NO) is most important as it destroys 50 to 70% of ozone (Kemp. 1994). NO is formed by the oxidation of Nitrous oxide (N_2O) emitted by the denitrifying bacteria in the soil. Air crafts flying at high altitude also emit oxides of nitrogen to affect the ozone layer. In the stratosphere the following reactions take place

$$N_2O + O \rightarrow 2\,NO$$
$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$

NO_2 is somewhat beneficial. It readily combines with chlorine monoxide (ClO) to produce chlorine nitrate ($ClONO_2$), a much less reactive compound, thus providing some protection to low stratospheric ozone (Kemp., 1994).

6. PROTECTING THE OZONE LAYER

Ozone layer can be saved by stopping the production of ozone-depleting chemicals as agreed in the Montreal Protocol. The Protocol was signed on 16 September, 1987. By now 127 countries have signed and agreed for elimination of production of CFCs by 1999.

Substitutes are already available for most uses of CFCs and others are being developed. CFCs in existing air conditioners and refrigerators must be recovered and recycled. Every year about 50 million refrigerators are discarded each containing about 1.2 Kg CFCs. In Germany one company is recovering and reusing CFCs from 6000 discarded refrigerators per month (Botkin and Keller, 1995).

The two potential substitutes for CFCs currently in use are Hydrofluorocarbon (HFC) and Hydrochlorofluorocarbon (HCFC). HFC does not contain chlorine but has fluorine which is approximately 1000 time less efficient in ozone depletion. HCFC has hydrogen and may break up in the lower atmosphere and thus not inject chlorine in the stratosphere. HCFC will still cause ozone depletion and is very expensive (Botkin and Keller, 1995). India has also taken steps to replace CFCs in refrigerators. Bombay based Godrej Appliances have started manufacturing refrigerators which do not contain CFCs. Recently, research in Germany has supported the use of butane and propane in a specific proportion as a potential substitute of CFCs in refrigerators and air conditioners. Another alternate being suggested is the use of hydrogen-hydride system for refrigeration. The chemical does not pollute atmosphere or damage the ozone layer (Veziroglu, 1997).

5. SUMMARY

1. The ozone layer in the stratosphere helps to shield the earth from harmful ultraviolet radiations. There is enough evidence that the amount of ozone in the stratosphere is declining and large ozone holes develop over Antarctica each year.
2. Ozone depletion has a number of serious environmental impacts including damage to the earth food chain and human health effects, including increases in skin cancer, cataract and suppression of immune system.
3. Increased UV radiation due to ozone depletion may disrupt the role of plankton as a sink of carbon dioxide with increased CO_2 levels in the atmosphere thereby causing global warming.
4. Ozone layer can be saved through stopping the production of CFCs as agreed in the Montreal Protocol. Recovery and reuse of existing CFCs and finding their substitute may help protect the layer. Due to long life of CFCs already in the air, the problem of ozone depletion will continue and would worsen sometimes between the years 2000 and 2020.

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EVALUATION OF ADEQUACY AND PERFORMANCE OF DRAINAGE INLETS OF SURFACE DRAINS

By

Muhammad Muneeb Khan* and Dr. Ata-ur-Rehman Tariq**

ABSTRACT

Drainage inlets are used to admit agricultural runoff from the catchment area into surface drain. Many operational conditions undermine the proper functioning of inlets and reduce its operational flexibility. Inadequate drainage will lead to degradation of drainage environment as localized flooding of cropped area, increased groundwater recharge leading to water logging and salinity which will reduce agricultural productivity to large extent. The causes of improper working of inlets included silt deposition, vegetation growth, inappropriate location, crest level of inlet above N.S.L. of the service area, physical destruction and inadequacy of drainage inlets. This field research was carried out to evaluate the causes of malfunctioning of drainage inlets under field conditions, study the adequacy of inlets before after the rehabilitation under National Drainage Program (NDP) and identify the improvement required to ensure proper functioning of the drainage inlets. From field experiments it is recommended that periodic cleaning of the drainage inlets should be done particularly before rain season in order to get rid of silt deposition and vegetation growth. Care should be taken at the construction stage, so as to establish crest level of the drainage inlet to be at 15-30 cm below the N.S.L. of the service area. It is also envisaged that 3 to 4 inlets should be provided on each side of the drain in conjunction with lead channel and raised embankment to improve runoff drainage capacity of the system and restrict flow of runoff over the drain bank everywhere except the inlet.

KEYWORDS

(Drainage inlet, overall performance, hydraulic performance, overall physical integrity)

INTRODUCTION

The drainage is defined as the removal and disposal of excess water from any area. Agricultural drainage is concerned with the removal of excess water from the plant environment to minimize any damage to the crops. The surface runoff may enter into the drain over the sides; but this could lead to erosion and sloughing of the banks. Thus in order to avoid erosion of drain side slope and silting of drain bed, entry of water into the drain should be regulated. The surface runoff is preferably admitted into the surface drains through specially constructed structures called **drainage inlets.**

The components of a typical inlet as shown in Figure 1 are: i. an inlet trough (optional), ii. Steel/RCC pipe or a masonry/concrete box flow, and iii. Stone riprap at bed and sides of the drain or a chute with suitable energy dissipation arrangements for protection against scour. The inlet trough facilitates collection of drainage water from the catchment area and conveys it to the RCC pipe. Then pipe or box barrel, which runs below the service road or spoil bank and extend from the inlet trough to the drain section, delivers drainage water to the drain prism.

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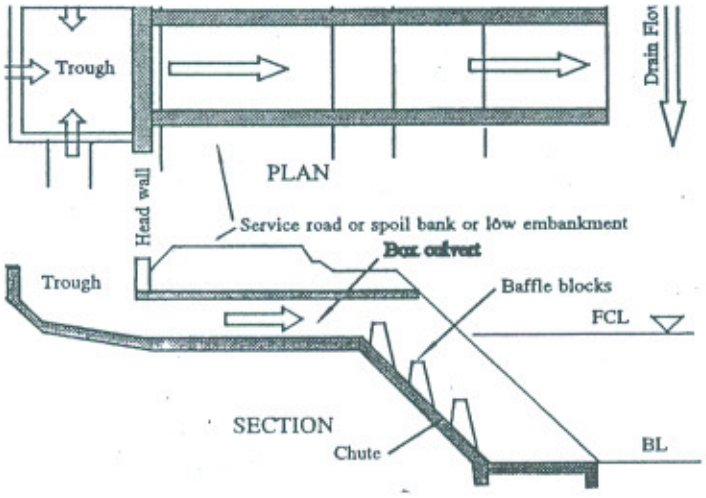


Figure 1 Components of Drainage Inlet

Failure of drainage inlets may result due to faults/overlooks, which have taken place during design stage, construction stage and operation stage. During the design stage the number, location, the discharge capacity of drainage inlet and the provision of lead channel are very important for successful operation of drainage inlets. There is no general rule about the number of inlets, which should be provided per mile length of the drain. Present yardstick followed by Water and Power Development Authority (WAPDA) and PID's is that two drainage inlets should be provided per mile length of the drain. The number and location of the inlet is dictated by site conditions. The discharge capacity of the drainage inlet should be proportional to area it will serve to avoid downstream overtopping and spilling.

During the construction stage setting the crest level of the drainage inlet is very important consideration. The crest level of the drain inlet should be below N.S.L., so that drainage water enters the drainage inlet freely. During the operation stage the growth of weeds, silt deposition in the drainage inlets, inadequate repair and maintenance are the causes of failure of drainage inlets. The growth of weeds and silt deposition decreases the discharge capacity of the drainage inlet and inadequate repair and maintenance will ultimately result in failure of drainage inlet.

In view of above facts, it is needed to explore the circumstances causing malfunctioning/ poor performance of drainage inlets under field conditions and evaluate correctional measures at design/construction/operation stage that will ensure trouble free and satisfactory performance of the drainage inlets. Recently drainage inlets and other structures had been improved/rehabilitated for few surface drains under National drainage Program. It will be interesting to investigate the sustainable performance of these inlets after the improvement program.

METHODOLOGY

Photographic Images of all the drainage inlets located in a 5 to 10 km. reach were taken for the selected drains. The performance parameters were evaluated by visual inspection, limited measurements and engineering judgment. Following points were noted at every drainage inlet:

- Location of the drainage inlet.
- Suitability of the inlet location with respect to its topological conditions of surrounding area.
- Crest level vs. N.S.L. of the service area. (above, below).

- Silt cover at inlet trough, inlet barrel and chute was noted, and for this information taken includes depth of silt deposition, Spread/extent of surface area over which silt was deposited and location (all over the area, entrance, exit, sides, middle).
- Vegetation at inlet trough, inlet barrel and chute was noted, and for this information taken includes density, height and stiffness of stalk.
- Presence of cuts and breaches along the length of the drain (indicating absence but requirement for an inlet).
- Structural condition of the inlet was observed and for this physical integrity at trough, chute, wing walls, barrel, culvert, slab and head wall was noted.

Relevant Scaling

To assimilate the status of the drainage performance in a statistical format, the qualitative aspects were assigned weightage and rating between 0 and 10, (0 and 10 being two extreme condition of very good /acceptable or very bad/unacceptable condition).

The location of drainage inlet is considered appropriate if inlet is located along the drain such that the runoff from whole catchment area can easily reach the inlet and drained off with or without lead channel. If the inlet is located along the drain near a pacca road, railway line, canal, kacha road etc then the location of the drainage inlet is not topologically appropriate, as all these linear structures divide the catchment area into two or more sub areas, and the drainage water from one area will reach the inlet easily whereas the drainage water from the other area will not reach the inlet.

Extent of silt deposition was scaled from 0 to 10 where 0 represent no silt deposition, 5 represent silt deposition over 50% of the area and 10 represent silt deposition over the whole area. Over all silt cover for a particular inlet was scaled from 0 to 10. This scale was assigned keeping in view cumulative effects of silt depth, extent of area (spread) and critical location. Overall silt Cover (O.S.C) is scaled of 0 to 10 and computed as under:

$$O.S.C = (DLt \times St + DLc \times Sc + DLb \times Sb)\,(10) / (300) \qquad \text{Eq. No. 1.}$$

Where as DLt, DLc and DLb represent the combined effect of silt depth and location of spread at trough, chute and barrel section. Whereas St, Sc and Sb represent the silt spread at trough, chute and barrel section.

Density of vegetation was scaled from 0 to 10 where 0 represent no vegetation cover, 5 represent sparse vegetation cover and 10 represent dense vegetation cover. The overall vegetation cover of a drainage inlet is scaled from 0 to10 and computed as under:

$$O.V.C = (HHt \times Dt + HHc \times Dc + HHb \times Db)\,(10) / (300) \qquad \text{Eq. No. 2}$$

Where HHt, HHc and HHb represent the combined effect of vegetation height and stiffness of stalk at trough, chute and barrel section. Where Dt, Dc and Db represent the density of stalk at trough, chute and barrel section.

Physical Integrity of the structure has been scaled from 0 to 10 where 0 represent complete deterioration, 5 represent partial deterioration and 10 represent complete structure with no deterioration. Over physical Integrity (O.P.I) of the structure is scaled from 0 to 10 and computed as under:

$$O.P.I = (Wt \times Pt + Wch \times Pch + Wb \times Pb + Wc \times Pc + Ww \times Pw) \qquad \text{Eq. No. 3}$$

Where Wt, Wch, Wb, Wc and Ww represent the weightage factor for trough, chute, barrel, culvert and wing walls. These weigthages are 15%, 20%, 30%, 30% and 5% for trough, chute, barrel, culvert and wing walls. Where Pt, Pch, Pb, Pc and Pw represent the physical integrity of trough, chute, barrel, culvert and wing walls.

Hydraulic performance refers to the ability of the drainage inlet to allow a specific discharge of water coming from the catchment area to get into the drain. Inlets could pass limited flow even under state of being silted up, vegetation growth or disintegration of structural support. Hydraulic performance of the drainage inlet has been scaled from 0 to 10 where 0 represent that no flow passes through the inlet, 5 represent that the inlet is 50% hydraulically efficient and 10 represent the inlet is 100% hydraulically efficient.

The scaling of the hydraulic performance of the drainage inlet is evaluated by engineering judgment by considering crest level Vs. N.S.L of the service area, suitability of inlet location, vegetation growth/silt cover and physical integrity of the structure.

Over all performance was scaled by considering the over all vegetation cover, over all silt deposition, over physical integrity of the structure and hydraulic performance. Over all performance of drainage inlet is scaled from 0 to10 and computed as under:

$$O.P = (2 \quad Wv \times O.V.C) + (2 \quad Ws \times O.S.C) + Wp \times O.P.I \qquad \text{Eq. No. 4}$$

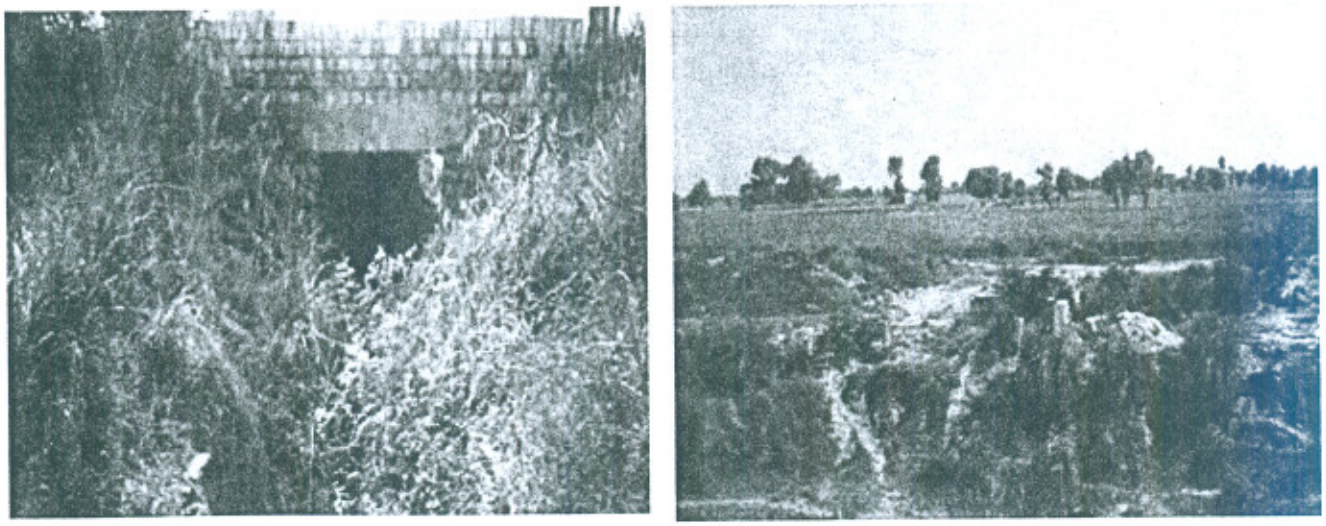
Where Wv, Ws and Wp represent the weight age factor for vegetation growth, silt cover and physical integrity. These weightages are 20%, 20% and 60% for vegetation, silt and physical integrity.

To evaluate the adequacy of drainage inlets the number of drainage inlets on the left and right bank of the drain was noted and length of the drain was also measured in miles. Cuts and breaches along the drain were noted to check the adequacy of drainage inlets. As we know that the present yardstick being practiced by WAPDA for adequacy of drainage inlets is that 2 inlets should be provided per mile length of the drain.

RESULTS AND DISCUSSIONS
DRAINAGE INLETS COMMON FAULTS

Vegetation Growth

Vegetation growth is very common fault found in almost every inlet. Of the total 148 inlets surveyed, 101 inlets were facing problem of vegetation growth. It was found in 16 inlets that have density of vegetation equal or greater than 7 and stiffness of vegetation was hard. If the vegetation cover is hard and dense, then it will decrease the hydraulic efficiency of the drainage inlet to larger extent and vice versa. Figure 2 shows dense vegetation with hard stiffness.



Mangoki, RD 28,710 L

Figure 2 Dense Vegetation with hard Stiffness.

Silt Deposition

Silt was found to be deposited at various sections (trough, barrel, culvert and chute) of the drainage inlet, causing partial to complete blockage of the inlet. Of the total 148 inlets surveyed, 95 inlets were having problem of silt deposition. In 15 inlets it was found that silt was ignorantly deposited by human interventions due to their irresponsible behavior. It was found in 30 inlets that silt was deposited in the trough section and completely blocks the inlet. Figure 3 shows silt deposition causing complete blockage.

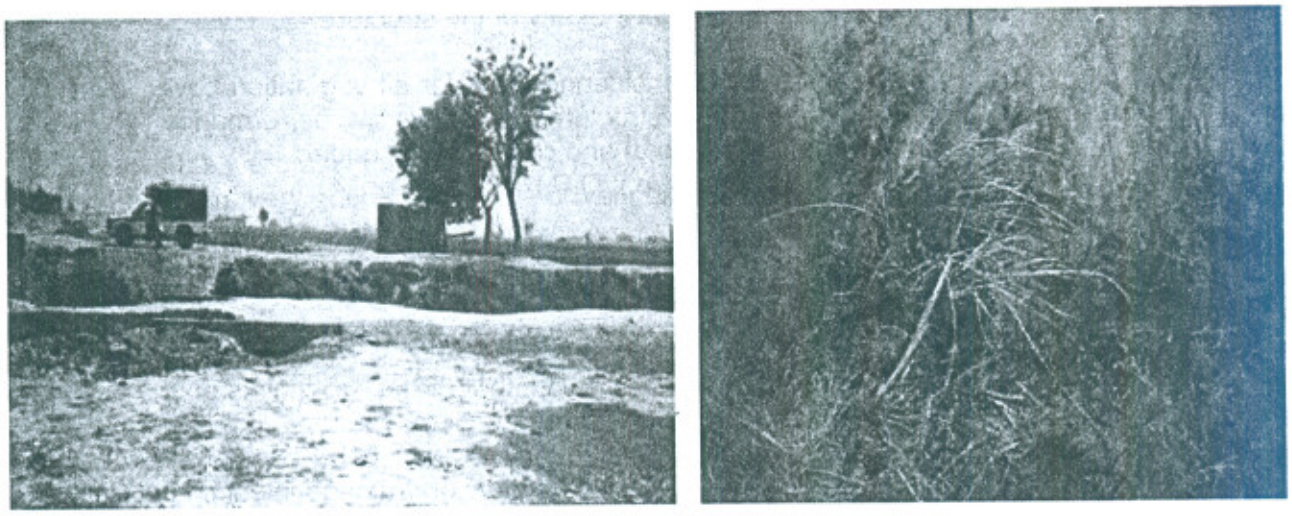


Figure 3 Silt deposition causing complete blockage.

Inappropriate Location

Of the total 148 inlets surveyed, 48 inlets were facing problems of inappropriate location. Figure 4 shows inappropriate location of the drainage inlet.



Raiwand, RD 119,685 L **Philloki, RD 87,927 R**

Figure 4 Inappropriate location of the drainage inlet.

Crest level of the Inlet above the N.S.L of the Service Area

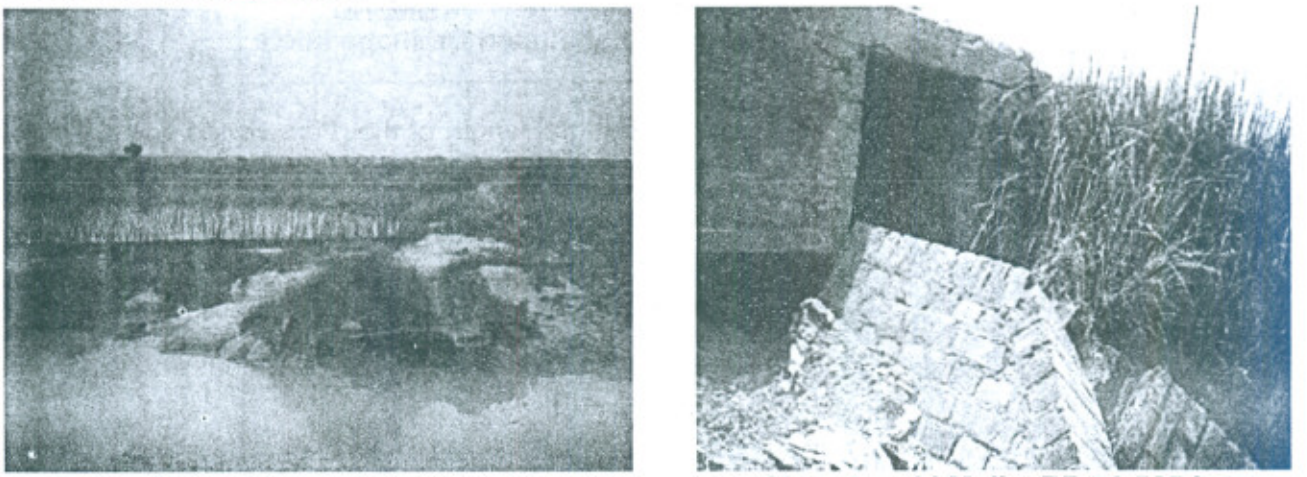
Of the total 148 inlets surveyed, 25 inlets were facing problem of crest level being above the N.S.L of the service area. The crest level of the drainage inlet should always be below the N.S.L of the service area when design of the drainage inlet is formulated. Figure 5 shows the crest level of the drainage inlet above the N.S.L of the service area.



Figure 5 Crest Level above the N.S.L of the area.

Physical Destruction of the Structure

Physical destruction of the structure is another common fault which also affects the hydraulic efficiency of the drainage inlets. Of the total 148 inlets surveyed 49 inlets were partially destroyed and 21 inlets were found completely destroyed. Figure 6 shows completely to partially deteriorated drainage inlets.



Ghazi, RD 34,768 L **Cheechoo ki Malia, RD 78,585 L**

Figure 6 Completely to partially deteriorated Inlets

Inadequacy of Drainage Inlets in Term of Fewer number

Total of 88 cuts and breaches were observed and 15 pipes were laid by the collective efforts of the farmers. Provision of lead channel can also cut down the requirement for inlets 10 lead channels were observed. Figure 6 shows the inadequacy of drainage inlets.



Figure 7 Inadequacy of Drainage inlets.

NDP REHABLITATED DRAINS

Miana Gondal, Faqirian Silan Wali and TBM were among those drains which were rehabilitated under NDP. There was no problem of vegetation growth, silt cover and physical deterioration in rehabilitated drainage inlets, but only two rehabilitated drainage inlets were observed over a distance of 5.4 miles indicating severe inadequacy. In TBM drain, inlets which were not rehabilitated were totally blocked by silt deposition, indicating very severe problem of inadequate maintenance, as for other drains.



Faqirian Sian Wali, RD 3,655 L



TBM, RD 19,550 R

Figure 8 NDP Rehabilitated Drainage Inlets

CASE STUDY OF GHAZI DRAINAGE SYSTEM

Ghazi drain is located in district Sheikupura. The total length of the drain visited was 5.2 miles and total number of inlets on left and right side of the drain were 4 and 18. This drain was surveyed from RD 42,182 to RD 14,758. Performance evaluation data of Ghazi drain is given in Table 1, and schematic bar chart for performance of Ghazi drain is shown in Figure 9.

Silt Deposition

The number of silted and non silted inlets were 13 and 9, overall silt cover in drainage inlets varied from 1to 10, whereas average overall silt cover was 3.6. There were 6 inlets with overall silt cover equal or greater than 7, having average silt depth of 45 cm, as shown in Figure 9.

Vegetation Cover

The number of vegetated and non vegetated inlets were 16 and 6, overall vegetation in drainage inlets varied from 1 to 8, whereas average over all vegetation cover was 2.9. There were 3 inlets with overall vegetation cover equal or more than 5, having 65 cm of average height as shown in the Figure 9.

Physical Integrity

Overall Physical integrity of drainage inlets varied from 0(worst condition) to 9 (best condition), whereas average overall physical integrity was 4.2. There were 11 inlets with overall physical integrity equal or less than 3 as shown in the Figure 9.

No of Inlets

The number of inlets provided on the left and right sides of the drain were 4 and 18 over a length of 5.2 miles. Thus less than one inlet is provided per mile length of the drain on the left side, and 3 inlets were provided per mile length of the drain on the right side. There were 30 cuts observed, 15 on right and 15 on left side of the drain.

Hydraulic Performance

The hydraulic performance of drainage inlets varied from 0 (worst condition) to 10 (best condition), whereas average hydraulic performance was 4.3. There were 8 inlets which had hydraulic performance equal or less than 3 as shown in the Fig 4.13.

Overall performance:

Overall performance of the drainage inlets varied from 0 (worst condition) to 9 (best condition), whereas average overall performance of the drainage inlets was 4.There were 7 inlets with overall performance equal or less than 4 as shown in the Fig 4.13.

Table 1: Performance evaluation data of Ghazi drain.

No.	RD	Silt Cover (D = depth cm, S = spread, L = location)										Vegetation cover (D = density, H = height cm, S = stiffness)										Location	Invrt level	Physical Integerity/Structural destruction						Hydraulic Performance	Overall Performance
		Trough			chute			Barrel			O.S.C	Chute			Trough			Barrel			OVC			Trough	Chute	Barrel	wing wall	culvert	Overall		
		D	S	L	D	S	L	D	S	L		D	H	S	D	H	S	D	H	S											
1	42,084 R	25	4	s	0	0	-	0	0	-	1	2	20	me	3	20	me	6	30	ha	2	A	b	0	10	10	10	10	9	10	9
2	39,033 R	40	5	en	60	5	oa	60	10	oa	10	4	20	me	5	60	ha	4	20	me	3	A	b	0	0	10	0	10	6	0	5
3	36,080 R	80	10	en	0	0	-	50	10	oa	8	1	20	so	4	30	me	-	-	-	1	A	a	0	7	0	0	5	3	0	4
4	35,096 R	30	5	en	30	10	oa	30	6	oa	7	6	50	ha	0	0	-	6	30	me	3	A	b	0	5	5	0	7	5	6	5
5	34,768 R	0	0	-	0	0	-	-	-	-	0	2	30	so	5	60	ha	-	-	-	2	A	b	0	7	0	0	8	4	7	6
6	34,768 L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0
7	32,471 R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	a	0	0	0	0	0	0	0	0
8	28,862 R	50	7	en	-	-	-	-	-	-	7	-	-	-	5	30	me	-	-	-	1	A	b	0	0	0	0	7	2	5	7
9	28,206 R	20	2	s	25	2	oa	-	-	-	1	5	30	me	4	60	ha	5	50	me	3	A	b	0	0	0	0	10	3	5	5
10	25,253 R	70	10	s	0	0	-	0	0	-	2	6	75	ha	5	60	ha	5	60	me	5	A	b	0	10	10	5	10	8	8	7
11	25,089 R	0	0	-	0	0	-	0	0	-	0	6	60	ha	3	60	me	5	30	so	3	A	b	0	10	10	0	7	7	8	8
12	22,956 R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0
13	20,988 R	0	0	-	30	6	oa	30	4	s	3	3	30	me	6	60	ha	3	30	me	3	A	b	0	10	10	10	10	8	8	8
14	20,988 L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	3	0
15	20,332 R	0	0	-	0	0	-	0	0	-	0	0	0	-	0	0	-	0	0	-	0	A	b	0	0	0	0	10	3	5	5
16	18,692 R	30	6	oa	30	7	s	30	7	s	5	10	60	ha	6	60	ha	8	60	ha	8	A	b	0	0	0	10	10	4	2	3
17	19,348 R	70	8	en	40	5	s	-	-	-	9	7	60	ha	2	30	me	5	60	me	4	A	a	0	10	10	10	10	9	0	7
18	19,348 L	0	0	-	0	0	-	0	0	-	0	0	0	-	0	0	-	0	0	-	0	I	b	0	0	5	0	0	2	5	5
19	16,723 R	0	0	-	30	3	oa	30	5	oa	3	10	90	ha	4	60	ha	7	60	ha	7	A	b	0	0	0	0	10	3	5	4
20	16,066 R	30	5	en	30	5	oa	30	5	s	7	4	60	me	0	0	-	3	30	me	2	I	b	0	10	4	0	10	6	6	6
21	15,409 R	0	0	-	25	4	s	30	3	oa	2	4	60	me	4	60	ha	3	30	me	3	A	b	0	10	10	0	10	8	8	8
22	14,753 L	0	0	-	0	0	-	0	0	-	0	5	60	ha	2	20	so	2	20	so	2	I	b	0	0	0	0	7	2	4	5
	Average	24.7	3.2	-	17.6	2.8	-	20.7	3.5	-	3.6	4.4	42.6	-	3.2	37.2	-	2.9	34.3	-	2.9	-	-	0	4	4	2	7	4.2	4.3	4.8
	Maximum	50	10	-	30	10	-	45	10	-	10	10	90	-	6	60	-	8	60	-	8	-	-	0	10	10	10	10	9	10	9
	Minimum	0	0	-	0	0	-	0	0	-	0	0	0	-	0	0	-	0	0	-	0	-	-	0	0	0	0	0	0	0	0

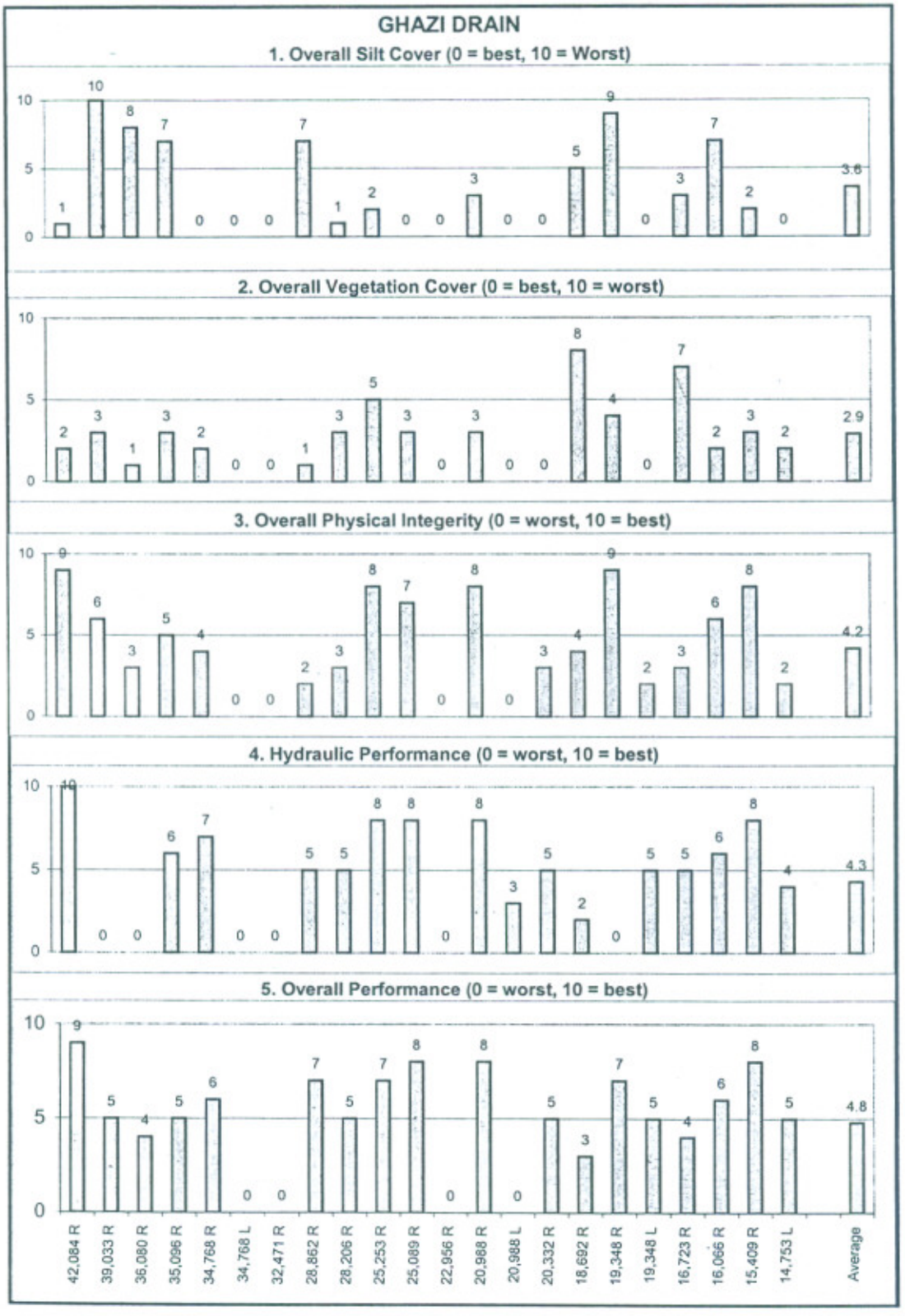


Figure 9 : Performance of Ghazi Drain.

OVERALL PERFORMACE OF DRAINAGE INLET

Overall performance of al the drains is shown in figure 10. Average overall silt cover in all the drainage inlets surveyed was 3.5. TBM, Koth Nala and Philloki were among those drains which impose large restriction to drainage flow due to substantial silt cover. Average overall vegetation growth in all the drainage inlets surveyed was 2.3. Raiwand, Hudiara and Faqiria Silan Wali drains were among those drains which impose large restriction to drainage flow due to substantial vegetation growth. Average physical integrity of all the drainage inlets surveyed was 4.6. Raiwand, Ghazi, Hudiara, Philloki, Baharianwala and Faqirian Silan Wali were among those drains which had very poor overall physical integrity. During the survey of 10 drains, 68.2 miles distance was covered and 148 inlets were observed. Whereas the number of inlets provided per mile length of the drain on average was 2 which is in accordance with the criteria laid by WPDA for adequacy. However the criteria of 2 inlets per mile length of the drain was in general not adhered properly. Average Hydraulic Performance and Overall performance of all the drains surveyed was 4.0 and 5.4.

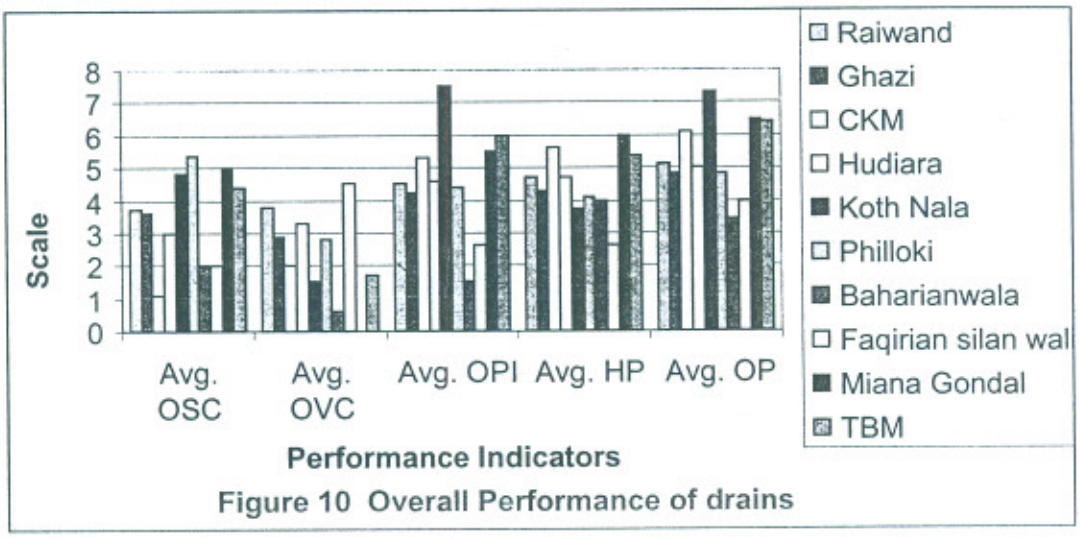


Figure 10 Overall Performance of drains

LEAD CHANNEL

It is viewed that if lead channel (of adequate length) provided at all inlets, then adequacy of inlets will improve considerably even for smaller number of inlets. This would also improve the siltation problem in the drain as lead channel will eliminate cuts and breaches. It is considered that a raised bank should be provided to stop entry of drainage runoff every where except through an inlet. Further three to four drainage inlets be provided per mile on both sides of the drain. Lead channel should be provided at the edge of ROW for larger part of drain length on both sides to guide drainage runoff from every part of the catchment area into the inlet. This will also eliminate the need by the farmers to block the inlet at entrance.

CONCLUSIONS

- Of the total 148 inlets surveyed, drainage inlets were found to have problems of silt deposition (95 inlets, 66%), vegetation growth (48 inlets, 32%), structural destruction (complete destruction-21 inlets, 14%; partial destruction-49 inlets, 33%), crest level above the N.S.L of service area (25 inlets, 17%), inappropriate location (48 inlets, 32%). Such poor state of inlets is due to utter neglect in maintenance.
- Average hydraulic performance, overall performance and overall physical integrity was 4, 5.4 and 4.6 and can be regarded as bad condition.

- The number of inlets provided per mile length of the drain was found to be inadequate (right side range- (0-3.46), Avg. 1.3; left side range – (0.37-3.26), Avg. 1.3). The number of inlets are inadequate.
- Lead channel, where present, were found to facilitate the drainage water into the drainage inlet.
- Rehabilitation of drains under NDP have considerably improved the performance and structure of the inlet.

RECOMMENDATIONS

- Periodic cleaning of the drainage inlets should be done particularly before rainy season in order to get rid of silt deposition and vegetation growth.
- Periodic repair and maintenance of inlet structure must be done.
- Three to four drainage inlets should be provided per mile on each sides of the drain to provide adequate drainage of the service area.
- Care should be taken at the construction stage, so as to establish crest level of the drainage inlet to be at 15-30 cm below the N.S.L of the service area.
- Lead channel should be provided in order to guide runoff from further parts of the service area into the drainage inlet.
- Raised banks should be provided on both sides of the drain to avoid cuts and breaches.

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SOCIAL IMPACT ASSESSMENT OF SUBSURFACE DRAINAGE

By

Aftab H Azhar, M. Rafiq and M. M. Alam*

ABSTRACT

Social impact assessment of four drainage projects namely; Mardan SCARP Project (MSP), Fourth Drainage Project, Faisalabad (FDP), Chashma Command Area Development Project (CCADP) and Mirpurkhas Tile Drainage Project (MKDP) has been done. For this purpose, a socio-technical survey was carried out in which randomly selected farmers were interviewed. The investigations revealed that although significant population (~77%) at four study sites was educated, yet, the farmers were not satisfactorily educated to understand the operation & maintenance of drainage systems. The perusal of data revealed that 14%, 17% and 25% respondents from MSP, FDP and MKDP respectively had to migrate from their villages mainly due to pre-project waterlogging problem. However, installation of drainage systems in those areas improved the situation resulting in the increase of farm income, which was an attraction for them to return to their villages. The analysis of farm mechanisation revealed that at MSP, FDP, CCADP and MKDP sites 71%, 42%, 40% & 75% respondents respectively were tractor owners and owners of some kind of other farm implements, whereas, remaining respondents were performing their farm operations on hire basis. Although, hire operation basis is much better than traditional ways, however, improving the farm mechanisation could further enhance the benefits of drainage systems. The investigations revealed that a significant majority of respondents at four project sites had never met the Agricultural Extension Officer. The farmers' access to financing institutions such as ZTB was also negligible. There was lack of coordination among various departments such as WAPDA, Agriculture Extension and Irrigation & Power Department at four study sites. Nevertheless, the overall social impact investigations did reveal that the objectives of drainage systems installation have been achieved in terms of uplifting the socio-economic conditions of drainage areas. To make the efficient use of existing drainage systems, interdepartmental interaction among above mentioned departments should be made positive in those areas, and lack of commitment on one's behalf should be dealt with by imposing negative sanctions to that quarter. While realizing the adverse impacts of drainage systems, it is recommended that when planning future drainage projects, all the related issues must be considered and addressed so as to avoid post-project complexities affecting the beneficiaries.

1. INTRODUCTION

Irrigated agriculture is the backbone of Pakistan's economy. The livelihood of more than 70% population of Pakistan is directly or indirectly supported through this sector. Waterlogging and salinity are the two major factors responsible for low agricultural production in the country. In order to capture this twin menace, numerous methods such as mechanical and biological reclamation have been applied by WAPDA, under the Salinity Control And Reclamation Projects (SCARPs). As such, a considerable part of past investments (~ Rs.37 billions) of the water-sector has gone to remedy the situation (Azhar et al., 2004c). Among various methods adopted, the subsurface pipe drainage technology was introduced in Pakistan about three decades ago to control waterlogging and salinity. To-date, eight drainage projects have been completed in various provinces of the Pakistan. Different aspects of subsurface drainage systems have been investigated by various researchers (Iqbal et al., 1997 ; Azhar et al., 2004 b, c & d). However, not much attention has been paid to look into the social impact assessment aspect of these systems. Considering the huge investments incurred and the benefits attached with those projects, there is a great need to evaluate the social impact of those systems and to suggest improvements for future drainage projects. As such, this study was conducted by IWASRI.

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Under this study, above four pipe drainage projects were evaluated in terms of social impact assessment as discussed below.

2. STUDY AREA

In order to capture the problem of waterlogging and salinity, to-date eight drainage projects have been installed in various provinces of Pakistan. As stated earlier, for this study only four sites viz. MSP (*NWFP*), FDP (*Punjab*), CCADP (*NWFP*) and MKDP (*Sindh*) have been selected (Figure 1). These project sites have been selected based on their wide range of geohydrological and climatic conditions. In addition, these sites cover a range of old as well as most recently installed pipe drainage systems in different provinces of Pakistan. This range of selection would facilitate to evaluate the social impact assessment of subsurface drainage systems that were designed using old and new technology. The salient features of these four selected project sites are given in Table 1. For details of these project sites, reader is referred to Azhar et al. (2004a).

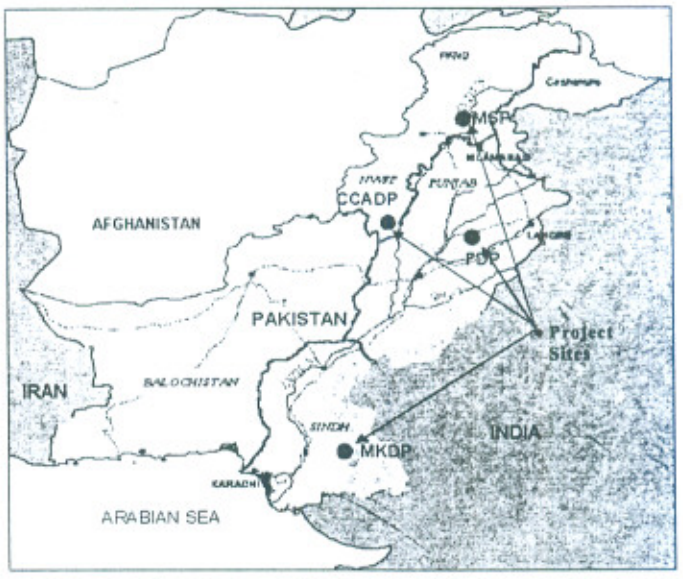


Figure 1 Location Map of Selected Drainage Projects

Table 1 Salient Features of Selected Drainage Projects

DESCRIPTION	MSP	FDP	CCADP	MKDP
Gross area	50,020 ha	52,609 ha.	63,509 ha	-
Tile drainage area	29,542 ha	30,351 ha.	60,936 ha	24,281 ha
Installation. Period	1983–92	1988–94	1984-94	1994–97
Mean annual rainfall	542 mm	356 mm	250 mm	150 mm
Design WT depth	140 cm	122 cm	140 cm	122 cm
No. of units/sumps	385	79	65	52
Type of outlet	Gravity	Pumped	Pumped	Pumped
Executive agency	WAPDA	WAPDA	WAPDA	WAPDA
Total costs (PC-I)	Rs 673×10^6 (1981)	Rs 1127×10^6 (1988)	Rs 1127.800 million	Rs 2473 million

(After Azhar et al., 2004a)

3. MATERIALS & METHODS

In this study *social impact assessment* aspect of four selected projects has been discussed. The diffusion and adoption of innovations is a complex process. There is always a time gap, sometimes lasting for years between gaining the first knowledge/awareness of an innovation before a final decision is made whether or not to adopt it. Unless the beneficiary (farmer) is properly educated and understands the merits of an innovation, the adoption process becomes not only difficult but also quite often the innovation is actively resisted (Ijaz and Davison, 1997). In this study, an effort was made to investigate the social impact aspect of subsurface drainage technology which was already installed in the study areas. This seems quite important so that remedial interventions could be made to enhance the benefits of those drainage systems. For this purpose, a socio-technical survey was carried out by IWASRI consultants at four study sites in which randomly selected beneficiaries (farmers) were interviewed. A sample questionnaire developed for socio-technical survey is given in Azhar et al.

(2004a). The collected data were first screened for their integrity, and then analysed in various ways to arrive at the social impact assessment of four drainage projects selected for this study.

4. RESULTS AND DISCUSSIONS

The social impact assessment of various project sites is discussed hereunder:

4.1 Education Status

Literacy rate is the yardstick of development and reflects the socio-economic conditions of the society. Literate farmers are better able to gain access to new ideas and technologies through the dissemination of pamphlets and posters. Better educated people are also more willing to adopt new ideas and technologies. In view of its importance in drainage areas, literacy information were collected and the distribution of respondents was made viz illiterate, primary, middle, matric, F.A/FSc & above. Based on this distribution, survey results of four study sites are graphically represented in Figure 2. The perusal of Figure 2 reveals that on average significant population (~77%) of respondents at four study sites was educated. Among literate the percentage of F.A./FSc & above level schooling was the highest i.e. 33%. The overall education status at four study sites in the order from illiterate to the highest level schooling can be listed as: Illiterate (23%), Primary (12%), Middle (14%), Matric (18%) and F.A./FSc & above (33%). Whereas, in the chronological order from the highest percentage of respondents to the lowest can be expressed as: F.A./FSc^{+} (33%) > Illiterate (23%) > Matric (18%) > Middle (14%) > Primary (12%). The survey indicated that 14% had passed middle and 18% had passed matric, which is considered to be well educated in a rural community (Alam et al., 2000).

As stated earlier, literate farmers are better able to gain access to new ideas and technologies through the dissemination of pamphlets and posters. By the same token, they can communicate better and provide reliable information during the socio-technical interviews such as conducted for this study. As such, the education status distribution at four study sites (Figure 2) indicated how reliable/sound information had been collected for this study. Since, better educated people are also more willing to adopt new ideas and technologies, hence, above given education distribution indicates how various farms operated by educated farmers could better be benefited from the operation of drainage systems in those areas.

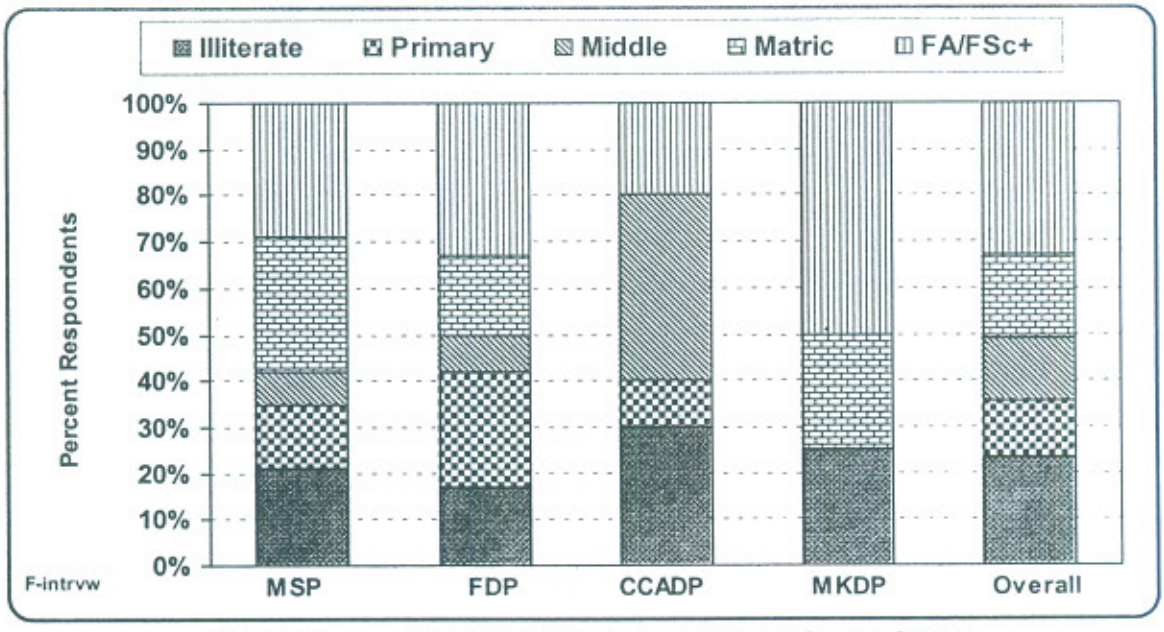


Figure 2 Education Statuses at Four Study Sites

4.2 Land Holding Status

In agriculture, land holding is of paramount importance and considered to be one of the leading factors in increasing farm productivity. Small size holdings are relatively expensive to operate and usually lead to wastage and inefficient use of both labour & capital resources. On

the other hand, large landholders are conductive to the adoption of improved farm technology. Generally, the farms are divided in to three categories namely; *small* (<5 ha), *medium* (5 to 10 ha) and *large* (>10 ha) depending upon the area under cultivation. Based on this categorisation, the distribution of respondents by virtue of their land holdings at four study sites is graphically shown in Figure 3. As can be observed, at MSP, FDP, CCADP and MKDP study sites 60%, 33%, 40% and 0% farms respectively were small. Similarly, at those study sites 5%, 50%, 30% and 0% farms respectively were medium. Whereas, 35%, 17%, 30% and 100% farms respectively were large. Generally, the larger the size of farm better would be the benefiting impact of drainage system operation on that farm. As such, the farm distribution at four study sites (Figure 3) indicated how various farms at those study sites were benefited from the operation of drainage systems in respective areas.

4.3 Tenancy Status

Tenurial status plays an importance role in receiving the benefits from drainage technology. Normally, three types of tenancy systems viz; owner, owner-cum-tenants (i.e. operating one's own land & also renting some additional land) and tenants (i.e. operating the renting land), were present in the drainage areas. Generally, the owners are much more willing to make capital investments in their lands. The owner operated farms (especially large landholdings) have relatively more potential for benefiting from the subsurface drainage activity. As such, the tenancy status distribution at drainage site depicts how various farms at that site can better be benefited from the drainage activity in that area. Based on above categorisation, the analysis of surveyed respondents revealed that tenants group existed only at MSP site among the four study sites having a very low percentage of 7%. The largest category was owner, covering a range of 79% (MSP) to 100% (CCADP & MKDP) respondents. Whereas, owner-cum-tenant group was existing at two study sites 14% at MSP and 17% at FDP.

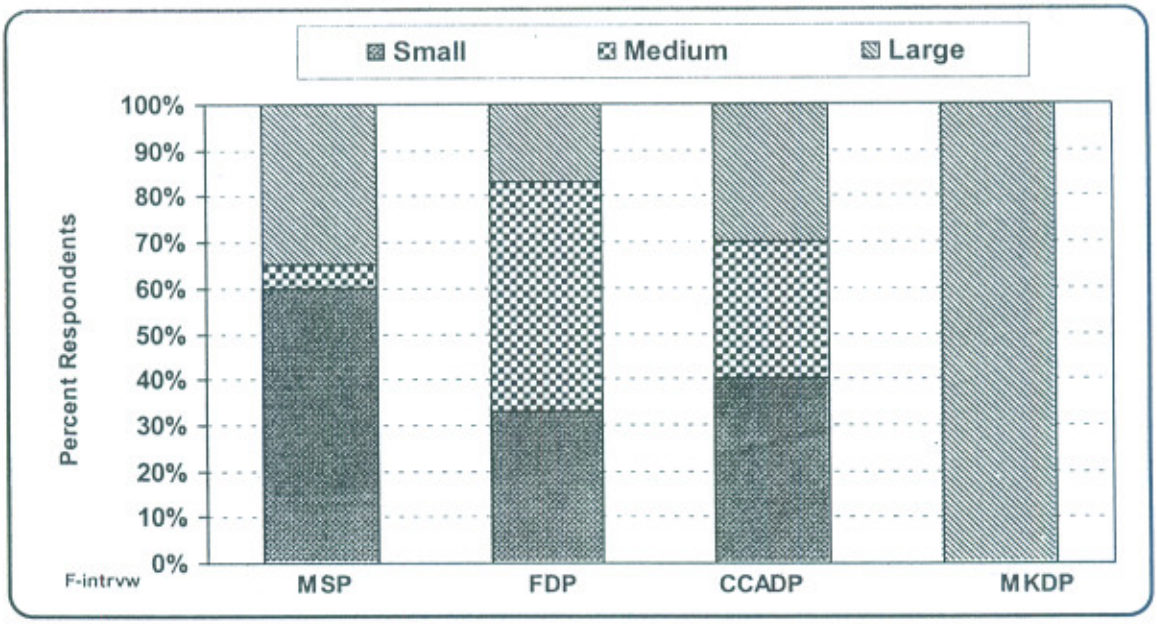


Figure 3 Distributions of Respondents by Virtue of Land Holdings at Four Study Sites

4.4 Farmers' Awareness Regarding Usefulness of Drainage Systems

With regards to the farmer's awareness about usefulness of drainage systems, it was noticed that almost 99% of the farmers at four study sites were familiar with the drainage projects usefulness. When asked about the positive effects on land, watertable, groundwater quality, soil salinity, farm income and crop yields etc., almost 100% of the farmers acknowledged appreciable impact of the drainage system installation in their areas.

4.5 Pre-Project Migration & Post-Project Increase in Farm Income

One measure of the severity of pre-project waterlogging & salinity menace is the pre-project migration by the people from their native villages to other areas. The lands begin to worsen due to waterlogging. During waterlogging, water begins to stand around the village resulting in increase of diseases, thus economically and mentally disturbing the people. Waterlogging brings snakes, shortens the fodder not only to create a hard environment for livestock but for the people as well who have to go far away to bring it. Consequently, people are compelled to leave their lands and migrate to cities to look for other alternatives for their livelihood. Migration is especially dominant among *small* landholders who are under relatively more stress. The *medium* and *large* landholders may also migrate merely to supplement their farm income. The pre-project migration status of people as surveyed at four study sites is given in Table 2.

As can be observed, 14% (MSP), 17% (FDP) and 25% (MKDP) respondents expressed that they had to migrate from their villages to cities mainly due to pre-project waterlogging problem. The exception was CCADP site, from where no respondent among the interviewed has been reported to migrate. As will be shown later under off-farm income (Section 4.6), the low percentages of migrants at MSP (14%) and FDP (17%) were mainly due to high percentages of respondents at those sites having off-farm employment as secondary occupation to supplement their family income. The 25% (MKDP) migration by big landholders may probably be attributed just to supplement their farm income for competing with the society. As told by the respondents/beneficiaries, the installation of drainage system in the affected areas improved the situation resulting in the increase of their farm income. Almost 100% of the respondents expressed that their farm income was significantly increased with the drainage activity in their areas, which was an attraction for them to consider returning to their villages (Table 2). Although, migration leads to increased awareness and higher education levels (IWASRI, 1997), it has inherent problems for migrants too.

Table 2 Respondents Distribution by Virtue of Pre-Project Migration & Their Perception About Post-Project Increase in Farm Income

Project Area	Pre-Project Migration (%)[+]		Farm Income Increase (%)[*]
	Yes(%)	*No(%)o*	
MSP	14	86	100
FDP	17	83	100
CCADP	-	100	100
MKDP	25	75	100

[+] *Percentages calculated from the number of respondents.*

[*] *Percentage calculated from the number of respondents having perception of an increase in their farm income*

4.6 Off-Farm Employment as Secondary Occupation to Supplement Family Income

Although, agriculture was the main source of family income at four study sites, yet maintaining the household was no longer possible solely through agricultural and animal production activity. Consequently, these activities in conjunction with other economic endeavours were prevalent and revealed the complexity in household's livelihood strategies. As is becoming apparent, off-farm employment, whether working for oneself, the government, or another individual, is an important source of cash for many households.

The respondents' distribution by virtue of off-farm employment as secondary occupation to supplement their family income at four study sites is graphically represented in Figure 4. As can be observed, significant percentage of respondents at MSP (71%) and FDP (92%) expressed off-farm employment as secondary occupation to supplement their family income. This high percentage can be attributed to the fact that household based agricultural activities frequently were not sufficient in meeting a household's cash needs and hence, required a

strategy of multiple income streams. As told by the farmers, among various reasons for adopting off-farm employment as second income source was *small* landholdings and/or shortage of irrigation supplies resulting in low crop production in those areas. As such, off-farm employment by household members was an important supplement to farm income in those study areas. A low percentage of respondents at CCADP (10%) and MKDP (0%) was perhaps mainly due to *large* landholdings, providing sufficient income for the families in those areas. Another, probable reason was that some of the farmers were reluctant to tell the truth due to fear of income tax. What additionally the survey data of Figure 4 also revealed was the unevenness in incomes among the four study sites, an indicative of the recognised prevailing image of socio-economic stratification across the country.

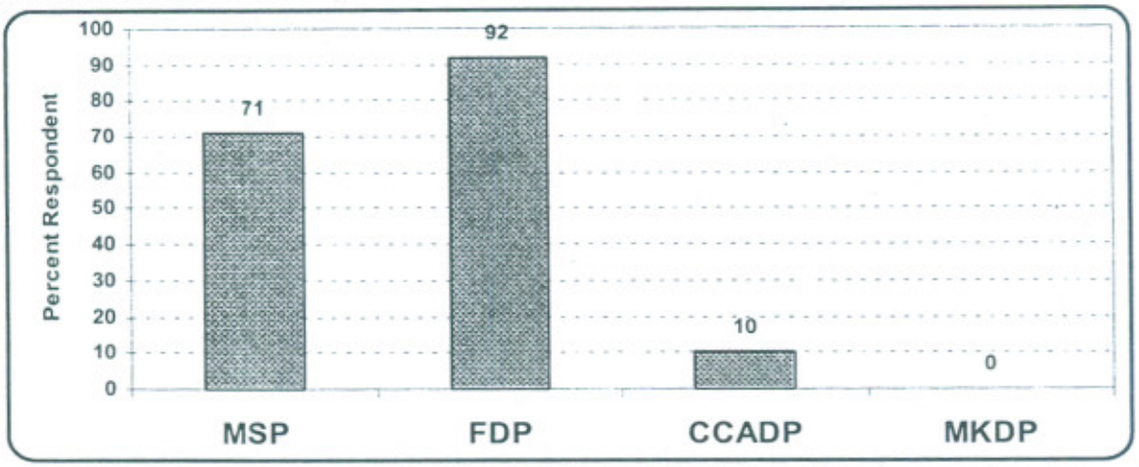


Figure 4 Respondents Distribution by Virtue of Off-Farm Employment as Secondary Occupation

4.7 Farm Mechanisation Status

Increasing agricultural production with the goal of promoting food self-sufficiency has been given top priority in the country. To achieve this objective, farm mechanisation plays a vital role. The benefits of drainage systems related to increased agricultural production can further be enhanced, if farms are adequately mechanised. The farm mechanisation status at four study sites is graphically shown in Figure 5. As can be observed at MSP, FDP, CCADP and MKDP, 71%, 42%, 40% and 75% respondents respectively expressed that they were tractor owners and owners of some kind of other farm implements. Whereas, 29% (MSP), 58% (FDP), 60% (CCADP) and 25% (MKDP) respondents were performing their farm operations on hire basis. Although, hire operation basis is much better than traditional ways, farm mechanisation could further enhance the benefits of drainage systems at those study sites.

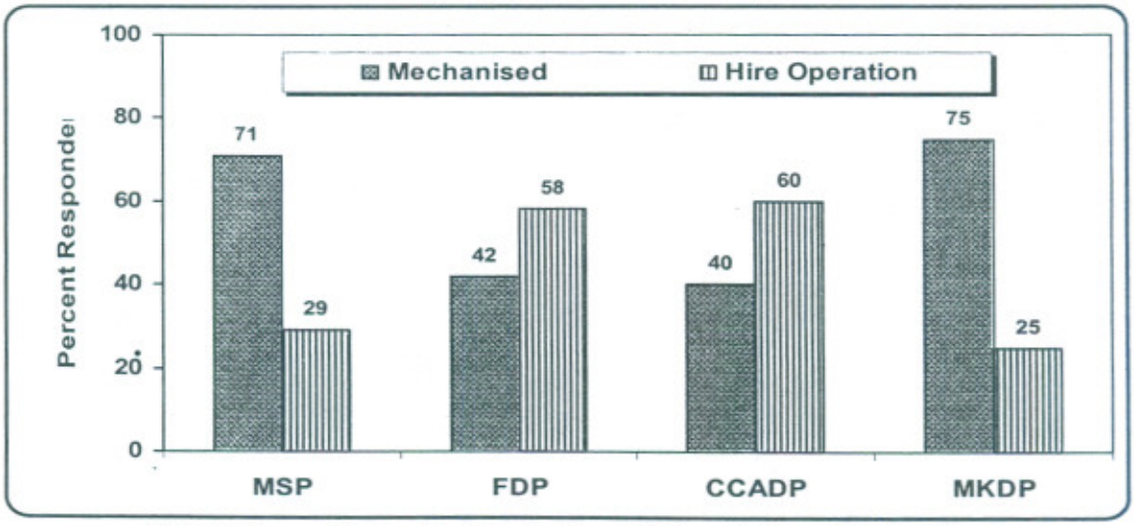


Figure 5 Farm Mechanisation Status at Four Study Sites

4.8 Agriculture Extension and Financing Services

During the survey, it was disconcerting to find that significant majority of drainage beneficiaries in the four study areas had never been to any agricultural exhibition, agricultural meeting, and research or demonstration farm. More than 90 % respondents of the project areas reported that they had never met the Agricultural Extension Officer. However, contact with junior staff was more encouraging. The farmers' access to the financing institutions such as ZTB was negligible as 90% respondents denied any contact with that institution.

4.9 Coordination Among Different Organizations

During the study survey it was noted that there had been very little coordination among WAPDA, Agriculture Extension Department and the Irrigation & Power Department. This lack of coordination was a major contributing factor towards the low benefits of the drainage projects at four study sites. This is because of the fact that the reduction in waterlogging leads to other new problems, which should have been addressed at the same time. For instance, the drainage systems' operation has lead to an increase in salinity, which can only be overcome through use of more irrigation water, plus gypsum. Lack of these two resources, partly due to the lack of coordination among government departments, has in some cases meant that drainage systems had lead to a decrease in production rather than an increase. For example, rice production levels were decreased after the change in the water level, without adequate irrigation water to make up the loss in water supplies. To get the maximum benefits from such projects in the future, it is very important that different departments coordinate properly. An interview with one of the respondents at FDP study site highlighted this aspect as below:

As reported by one of the respondents at FDP, after six months of the operation of drainage system lands began to dry and crops started to grow. The grass for the cattle gradually withered as lands remained no longer waterlogged and the fodder production improved. With these positive sings, another problem not less than waterlogging appeared in the form of salinity. To win over salinity, irrigation water was needed which was not sufficiently available. The land became well again where extra water was available. It was not possible to make the lands cultivable without irrigation water and gypsum after reduction in waterlogging. In his opinion, gypsum was also essential along with irrigation water. To stress his point further, he gave examples of his land which not only got irrigation water but gypsum as well and turned productive again. The land which did not get water despite getting gypsum was still uncultivable. This leads to the conclusion that not only new machinery but irrigation water and gypsum are also required to reclaim the land after reduction in waterlogging. He told that gypsum was available at subsidized rates only to influential farmers, and access to it was also difficult. This case was just an example, which strengthened the point of involving the beneficiaries during all the stages of projects not only for having better insight into the problem but for better planning and implementation to get more fruitful results from these projects. In essence, the information given by that respondent revealed the fact of lack of coordination among related departments, the absence of long term planning, the non-involvement & non-ownership of drainage sumps/outlets by the locals and poor agricultural/technical information transfer to the people for whom the projects are meant.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

i) The investigations revealed that the objectives of drainage systems installation have been achieved in terms of uplifting the socio-economic conditions of drainage areas.

ii) Although, significant (~77%) population of respondents at four study sites was educated, yet the farmers were not satisfactorily educated to understand the operation and maintenance of drainage systems.

iii) Land holding is one of the leading factors in benefiting from drainage activity.

Generally, larger the size of farm, better would be the benefiting impact of drainage system on the farm. The perusal of data indicated that at MSP, FDP, CCADP and MKDP, 35%, 17%, 30% & 100% respondents' farms respectively were *large*, whereas 5%, 50%, 30% & 0% farms respectively fell under *medium* category. As such, this distribution indicated how various farms at four study sites were benefiting from the drainage activity in those areas.

iv) The study revealed that 14%, 17% and 25% respondents from MSP, FDP and MKDP respectively, had to migrate from their villages to cities mainly due to pre-project waterlogging problem. The low percentages of migrants from MSP (14%) & FDP (17%) were mainly due to high percentages of respondents at those sites having off-farm employment as secondary occupation to supplement their family income. The 25% (MKDP) migration by *big* landholders may probably be attributed just to supplement their farm income without any crucial financial stress.

v) Installation of drainage systems in affected areas improved the situation resulting in the increase of farm income. Almost 100% of the respondents expressed that their farm income was significantly increased with the drainage activity in their areas, which was an attraction for them to consider returning to their villages.

vi) The analysis of farm mechanisation status at four study sites revealed that at MSP, FDP, CCADP and MKDP sites 71%, 42%, 40% and 75% respondents respectively were tractor owners and owners of some kind of other farm implements. Whereas, the remainder respondents were performing their farm operations on hire basis. Although, hire operation basis is much better than traditional ways, improving the farm mechanisation could further enhance the benefits of drainage systems in those areas.

vii) Significant majority of drainage beneficiaries had never been to any agricultural exhibition, agricultural meeting, and research or demonstration farm. More than 90 % respondents of the project areas reported that they had never met the Agricultural Extension Officer. The farmers' access to financing institution such as ZTB was negligible as 90% respondents denied any contact with that institution.

viii) There was lack of coordination among various departments such as WAPDA, Agriculture Extension and Irrigation & Power Department at four study sites. The technical/agriculture advice after reduction in waterlogging also seemed to be non-existent in the study areas. Further, neglecting poorer segments of society during any facility offered by government was also observed to be prominent in those areas.

ix) There exist certain adverse impacts associated with the drainage projects. For instance, the decrease in waterlogging due to drainage activity has resulted in increase of salinity which in turn has lead to increased dust and hence health problems, burdening families economically, physically and mentally.

5.2 Recommendations

- To make drainage systems more effective, there should be an organized farmers' motivation program existing in the drainage areas. This can be achieved by strengthening the agricultural extension services in those areas.

- Considering the multidimensional aspect of drainage projects, the interdepartmental interaction especially among WAPDA, Agriculture Extension Department and the Irrigation & Power Department should be made positive in the drainage areas. As such, their areas of interference & responsibilities should be made clear, and lack of

commitment on their behalf should be dealt with by imposing negative sanctions to respective quarters.

- By realizing the adverse impacts of drainage systems, it is recommended that while planning future drainage projects, all the related issues must be considered and addressed so as to avoid post-project complexities affecting the beneficiaries.

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PRODUCTION OF SPHEROIDAL GRAPHITE CAST IRON (S. G. IRON) FOR AN AUTOMOBILE BRAKE DRUM

By

***Dr. M. Taqi Zahid Butt and *Salman Aziz**

ABSTRACT

The role of automobile industry for any country has a great importance. Break drum is one of the essential parts of automobile car and its local casting is required in order to achieve the target for automobile industry because it has special significance. Break drum being the important constituent of the system of an automobile requires a great degree of accuracy & reliability. S. G. Iron is preferred because of its mechanical properties. i.e., higher strength modulus, impact resistance and ductility along with excellent machinability and manufacturing ease.

INTRODUCTION

In the present study sandwich method for the production of S.G iron is used to achieve the desired mechanical properties. The announcement [at the "AFS Casting Congress" held on May 7, 1948] shows that small addition of certain elements resulted in the formation of spheriodal graphite in as cast-iron. The independent studies in England at the British Cast Iron Research Association (BCIRA) using cerium additions and in the United States at the International Nickel Company (INCO), using magnesium addition, demonstrated the dramatic effect of these elements on promoting the formation of spheriodal rather than a flake graphite morphology during solidification is the key factor responsible for the unique mechanical and physical properties of ductile iron. Heat treatment was carried out after casting the brake drum and its mechanical properties were found excellent.

EXPERIMENTAL

Sandwich method was preferred for this type of casting. A ladle was designed consisting of two pockets by making a bright of refractory material into the bottom of the ladle. The Mg containing treatment alloy was placed into the bottom of the pocket and small pieces of steel turning or cast iron turnings, which was 2% of the charge melt free from dust, and rust were used as a cover to delay the vaporization reaction and experience showed that this method resulted in high Mg recoveries than were attainable with pour over method. Direct impingement of the liquid metal on the treatment alloys and ladle bottom should be avoided and the piece size of steel should be large enough to avoid any tendency to float, but small enough with a high surface area to volume ratio to melt reasonably quickly. Larger is the piece, slower is the reaction and in turn, greater is the heat loss. This delay in reaction is responsible due to excessive turbulence. The metal stream from the furnace was introduced in to the empty pocket which then produced a smooth flow of the metal across the bridge, thereby preventing the premature reaction. Mg recovery resulted from the effect of boiling through a layer of color iron.

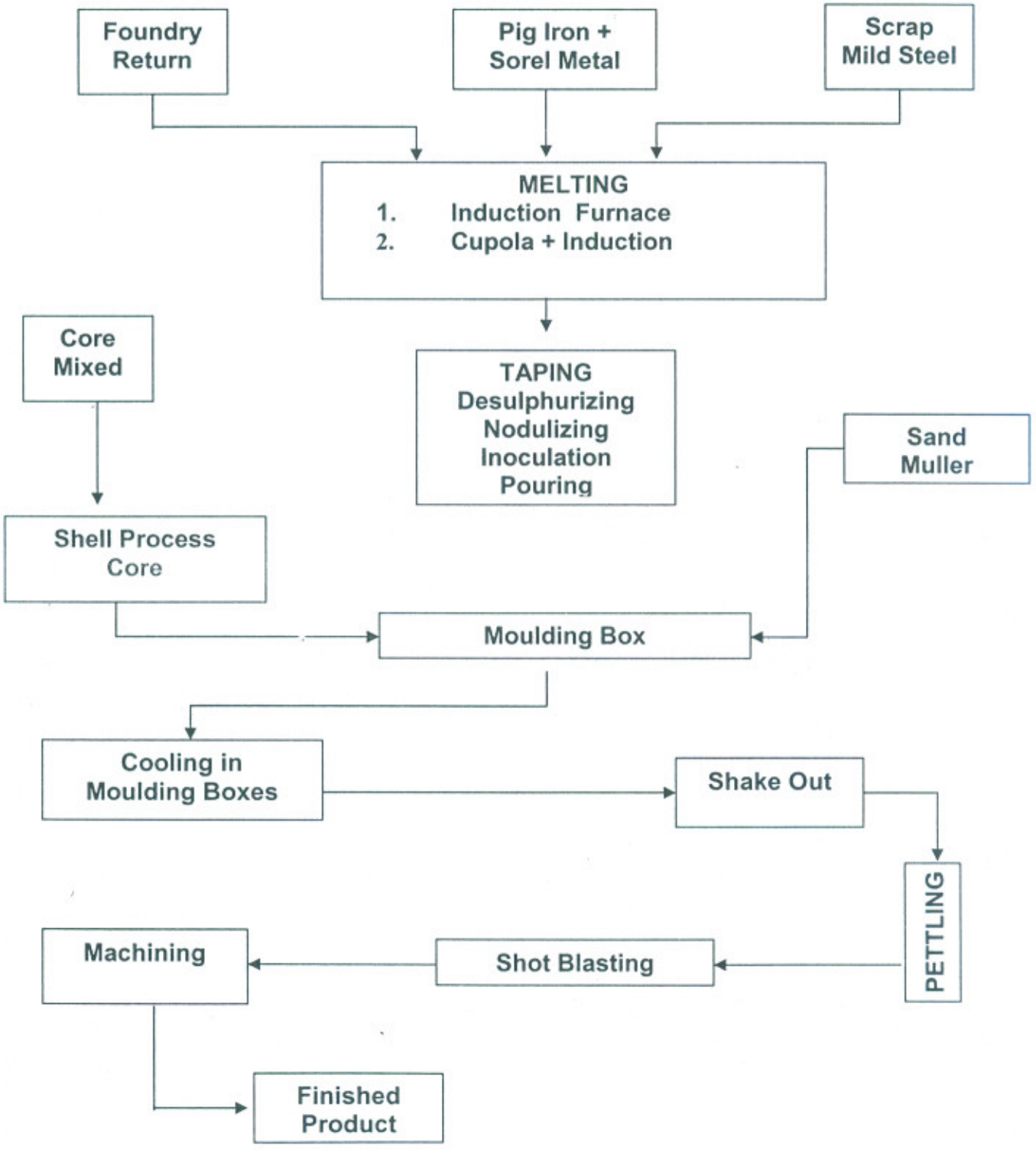
Melt was poured at temperature between 2500 and 2700 °F (1371 and 1482 °C). The metal chills against the mould wall leading at austenite crystals growing slowly though the melt and at the mould wall, a non pressurized gating system was recommended. Area ratio between sprue top and choke was according to pressurized gating systems and some graphitization of nodules occurred. The temperature fell slowly and a net decrease in volume occurred. The eutectic freeze begins with a sharp solidification front and a strong graphitization nodule growth resulting in a large volume increase. Pouring may be activated by pulling a plug, very much like in bottom pouring ladles, or by tilting the pouring device.

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Heat treatment of the casting involved the heating of the casting at a temperature of 900°C, because decomposition of carbides takes place at this temperature, and holding it for 2-6 hours.

After heating, casting was cooled to about 55°C below the lower critical temperature and held for 4-12 hours. The furnace temperature for slow cooling was allowed to fall below 600°C (595°C) before the castings were removed, after which the castings were air-cooled.

PROCESS FLOW CHART



RESULT & DISCUSSION

Different risers were used but for brake drum casting blind riser is proposed because in case of top riser cost will increase. There are many other advantages to prefer side risers because its considerable latitude is allowed in positioning the blind riser, it is smaller than a comparable open riser and also blind riser can be easily removed from casting.

Schimmel inoaculant is recommended because it contains calcium as an effective element that has been found to reduce white chill, increase the tensile strength & hardness also improves the machinability.

S. G. iron castings produced in non-rigid mould are more prone to shrinkage and to avoid shrinkage defects, the carbon equivalent should be maintained at or slightly above the eutectic level i.e. 4.3/4.5. If non-metallic inclusions are produced they will drastically reduce the mechanical properties. Magnesium should be retained as low as possible, conducive with obtaining fully spheroidal graphite throughout the pouring cycle. High initial S-content, low sulphur melting stock should be used and if sulphur thick-up occurs during melting, then desulphurization should be applied. Due to incorrectly designed running systems turbulent pouring may occur so it is always better to pour fast and smooth.

Soda ash apart from many disadvantages is perhaps the only desulphurizing agent that could produce a significant degree of desulphurization by simple addition in the ladle. In this practice 1% calcium carbide for two minutes was used for desulphurization:

TABLE:- 1 RECOMMENDED CUTTING SPEEDS FOR MACHINING S.G. IRONS

Type of S. G. Iron	Cutting Speed ft/Min.	
	High speed Tool steel	Carbide Tool
Red	75–150	250–500
Pearlite – Ferrite	50–100	200–350
Pearlitic	40–90	150–275

CONCLUSIONS

1. Mg recovery strongly depends on the treatment temperature.
2. Sandwich method is best for Mg recovery and also to reduce carbon losses.
3. Low pouring temperature should be preferred for heavy sections & the preferred temperature range is 1350-1450°C.
4. To avoid pinholes, which are caused by hydrogen of the moisture, use the dry mold.

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EFFECT OF FIBER CONTENT ON THE MECHANICAL PROPERTIES OF GLASS FIBER-PHENOLIC MATRIX COMPOSITE

By

Dr. A. Ahmad *, S. Akhtar and M. Yousaf

ABSTRACT:

Glass fiber-Phenolic matrix composite is used for the manufacturing of parts related to aerospace and electronic industry due to its high strength, dimensional stability and excellent electrical insulation properties. The evaluation of this composite material is necessary prior to make components/articles of new designs. In the present work, Thermosetting Phenolic plastic was reinforced with E-glass fiber, in different fiber-to-resin ratios to produce composites of different compositions. Mechanical properties of these composite materials were evaluated with reference to the effect of fiber content variation in phenolic resin.

INTRODUCTION:

Polymeric matrix composites (PMCs) have found extensive utilization in many areas of Manufacturing Engineering; especially the use of PMCs for aircraft structural applications has been swelled rapidly in recent years. Characteristics like high strength to weight ratio and high-modulus emphasize upon the importance of these composites not only in aerospace but for electronic industry as well. The bulk usage of these composites elevates their importance in the family of composite materials. [1].

Over 95 % of the fibers used in reinforced plastics are glass fibers as these are inexpensive, easy to manufacture and possess high strength and stiffness with respect to the polymers in which they are embedded. Their low density, resistance to chemicals and insulation capacity are other additional characteristics. The wide range of glass fiber variety lends them amicably to fabrication processes like die molding, filament winding, and lay-up method and so on. Glass fibers are available in the form of mats, tapes, cloths, continuous and chopped filaments, rovings and yarns. In the present work, investigation was carried out upon E-Glass fiber phenolic matrix composite material in which E-glass is used as reinforcement and Phenolic resin is used as matrix [2].

E-GLASS FIBER may be defined as a family of glasses with calcium aluminoborosilicate composition having maximum alkali content of 2.0%. It is a general-purpose fiber that is suitable for electrical laminates because of its high resistively, also called Electric glass (E-glass) [3].

PHENOLIC molding materials are high-performance thermosetting plastics. With the heat and pressure of molding process, thermosetting plastics react to form a cross-linked structure that yields excellent dimensional and thermal stability and superior load-bearing capability at elevated temperatures. Design engineers specify Phenolic for close-tolerance precision moldings that must function in hostile environments. [4].

EXPERIMENTAL:

Phenolic resin and E glass fiber used in the present work are tested prior to the preparation of composite materials with different resin to fiber ratios. Their properties are appended in the Table No. 1&2 respectively.

Sr. No.	Properties	Units	Values
1.	Density	g/cm^3	2.62
2.	Tensile Strength	Mpa	3445
3.	Elongation	%	4.88

TABLE No. 1 PROPERTIES OF E-GLASS FIBERS

University of Engineering and Technology Lahore

Sr. No.	Properties	Units	Values
1.	Resin content	%	65.02
2.	Kinematic Viscosity	mm/sec^2	15.54
3.	Density at 25 °C	g/cm^3	1.28
4.	Free Phenol	%	0.133

TABLE No. 2 PROPERTIES OF PHENOLIC RESIN

E-glass fibers of thickness 0.2 mm having length 30~50mm were manually mixed with resole type phenolic resin in different ratios to produce three composites, as mentioned in Table 3.

Sr. No.	E-glass fiber content (%)	Phenolic resin (%)
1.	30	70
2.	40	60
3.	50	50

TABLE No. 3: E-GLASS FIBER CONTENT IN PHENOLIC RESIN

Resin-impregnated fibers were dried at room temperature. These composites were then used to make samples for different mechanical tests by filling them in electrically heated molds under hydraulic press. The dimensions and weight of the specimens prepared for different tests are given in Table 4. Heating and curing temperatures of the molds are shown in Table 5.

Sr. No.	Tests performed	Dimensions (mm)	Weight (grams)
1.	Specific gravity	Cube	1-5
2.	Tensile strength	110x45x10 (LxWxT)	63±1
3.	Bending strength	120x15x10 (LxWxT)	33±1
4.	Impact strength	120x15x10 (LxWxT)	33±1

TABLE No. 4: DIMENSIONS AND WEIGHT OF SPECIMENS

Heating		Curing		
Temperature °C	Time Min	Pressure Kg/cm^2	Temperature °C	Time min
90~130	3~7	450 ± 50	160±5	10

TABLE No. 5: HEATING AND CURING TEMPERATURE

Microstructures of the composites are also examined. For this purpose, samples are polished up till ¼ microns by using Struers Metallographic Equipment and checked in as polished state. Fig.1, 2, and 3 depicts the microstructures of samples with fiber to resin ratio 30:70, 40:60, 50:50 respectively at 6X. Fig.4 reveals the microstructure of a sample with fiber to resin ratio 70:30 at 50X.



Fig.1 Fiber to resin ratio 30:70 (6X)



Fig.2 Fiber to resin ratio 40:60 (6X)

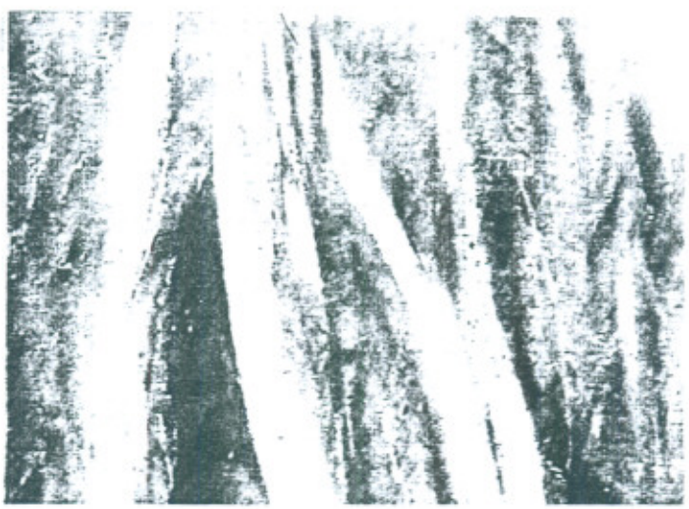


Fig.3 Fiber to resin ratio 50:50 (6X)

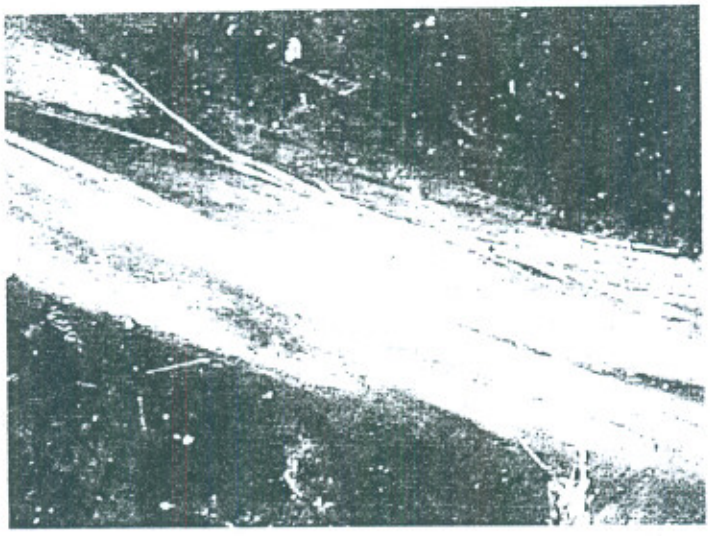


Fig.4 Fiber to resin ratio 70:30 (50 X)

RESULTS AND DISCUSSIONS:

As a result of increase of fiber content in the Phenolic matrix, the densities of composites have gradually increased. Densities presented in Table 6 are the result of average values of five samples of each composite mixed in ratios of fiber to resin 30:70, 40:60 and 50:50. As the E-glass fiber used in composite is acting as reinforcement therefore, it imparts profound effect on the mechanical properties of composite. To see how density variation or increase in fiber content affects mechanical properties, five samples of each composite were prepared for Tensile, Impact, and Bend strength.

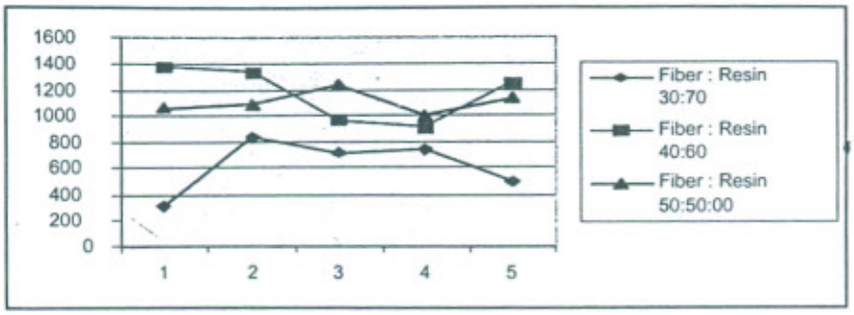
Sr. No.	Fiber content	Density(g/cm^3)	Volatile Content
1	30%	1.52	2.8%
2.	40%	1.68	4.9%
3.	50%	1.82	3.8%

TABLE No. 6: DENSITY AND VOLATILE CONTENT OF COMPOSITE MATERIALS

The effect of the fiber content on the Tensile strength has been shown in Table-7 for each five samples of all three composites wherein first has 30%,, second has 40% and third has 50% fibers. In composite having 30% fiber and 70% resin, the minimum Tensile strength is 310 kgf/cm^2 and maximum value is 828 kgf/cm^2 .

Sample No.	Fiber : Resin		
	30:70	40:60	50:50
1	310.0	1384.4	1066.4
2	828.9	1337.5	1082.5
3	709.8	960.4	1243.4
4	730.7	908.8	999.3
5	492.2	1245.4	1127.7

TABLE No. 7: EFFECT OF FIBER CONTENT ON TENSILE STRENGTH (Kgf/cm^2)



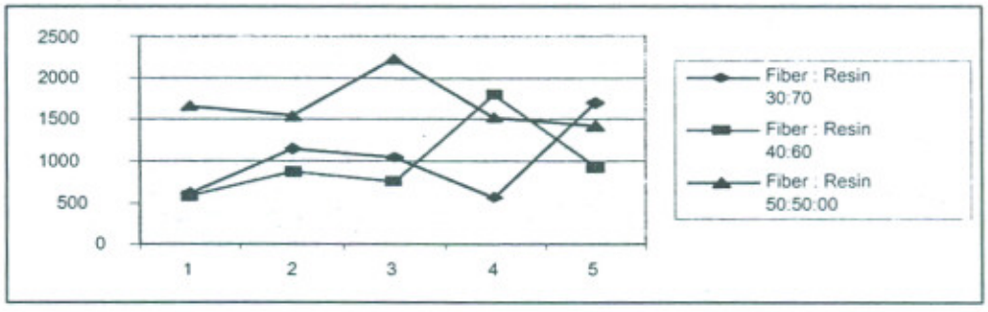
X-axis: Samples number, Y-axis: Tensile strength (Kgf/cm^2)

Fig.5 Effect of fiber content on Tensile Strength

Such variation in Tensile strength of same composite is might be the result of density variation of the samples. The other possible reasons of such results are the non-uniform structure of composite samples after solidification in die and due to the multidirectional orientation of the fibers in samples of the same composite as appeared in the macrostructures shown above in Figures 1~4. The other two composites that have 40% and 50% fibers also have shown more or less same behavior in Tensile strength. The results of bending strength and Impact strength of all three composites are presented in Table 8 and Table 9 respectively. The results of these two properties have also appeared in the same fashion as that of Tensile strength.

Sample No.	Fiber : Resin		
	30:70	40:60	50:50
1	609.1	586.9	1656.4
2	1140.7	869.3	1548.1
3	1051.7	750.5	2227.6
4	561.6	1802.2	1525.3
5	1693.8	932.1	1423.7

TABLE No. 8: EFFECT OF FIBER CONTENT ON BENDING STRENGTH (Kgf/cm^2)

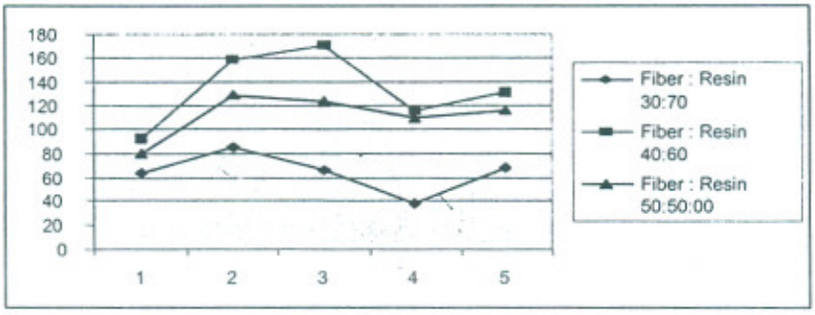


X-axis: Samples number, Y-axis: Bending strength (Kgf/cm^2)

Fig.6 Effect of Fiber content on Bending Strength

Sample No.	Fiber : Resin		
	30:70	40:60	50:50
1	64.4	92.6	79.9
2	85.5	158.8	129.3
3	66.5	169.9	123.7
4	38.8	115.6	109.9
5	68.2	131.1	116.6

TABLE No. 9: EFFECT OF FIBER CONTENT ON IMPACT STRENGTH (Kg. /cm)



X-axis: Samples number, Y-axis: Impact strength **(Kg. /cm)**

Fig-7 Effect of Fiber content on Impact Strength

However the most important fact arises here that average Tensile, Bend and Impact strengths increases gradually as the fiber content or the density of the composite increases. This fact is shown in Table 10 wherein the average values of five samples of each composite have been shown for Tensile, Bend and Impact strengths.

S.No.	Fiber content	Tensile strength Kgf/cm^2	Bending strength Kgf/cm^2	Impact Strength Kg/cm
1	30%	614	1011	64
2.	40%	1167	988	133
3.	50%	1104	1676	112

TABLE No. 10: COMPARISON OF MECH PROPERTIES BASED ON AVERAGE VALUES

CONCLUSION:

Mechanical properties of E-glass fiber Phenolic composite changes with change in fiber content of the composite. Table 6 reflects that density of the composite material increases with

increase of fiber content. From the Table 10, it is clear that with increase of 10~20 % in fiber content, tensile, bend and impact strengths of the composites improves remarkably.

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RECLAMATION OF IRRIGATED AGRICULTURE THROUGH PIPE DRAINAGE - CROPPING INTENSITY ANALYSES

By

Aftab H Azhar, M. M. Alam and M. Rafiq*

ABSTRACT

Four subsurface pipe (tile) drainage projects namely; Mardan SCARP Project (MSP), Fourth Drainage Project, Faisalabad (FDP), Chashma Command Area Development Project (CCADP) and Mirpurkhas Tile Drainage Project (MKDP) have been assessed in terms of their impact on improvement of irrigated agriculture. For this purpose, an impact/ performance indicator namely cropping intensity was investigated. The investigations revealed that total cropping intensities have been improved ranging from 19% (MKDP) to 67% (CCADP) as compared to the pre-project conditions. At MSP, the target value of cropping intensity (180%) was not only achieved but it showed an extra upward trend up to 230%. Similarly, at CCADP an upward trend of 162% was observed against the target value of 150%. The four study sites in terms of percent improvement in total cropping intensity in the order from maximum to minimum can be ranked/listed as: CCADP (67%) > FDP (54%) >MSP (40%) >MKDP (19%). This order of improvement indicates how various project sites were benefited from the drainage activity in those areas. As investigated, the main reasons for slow benefits at study sites were the limited financial resources available with farmers to reclaim/restore the fertility of waste lands, and shortage of irrigation supplies during the post-construction period to leach down the excess salts. This aspect revealed that efforts put to alleviate the problems of waterlogging & salinity through implementation of pipe drainage systems had not been up to the expectations mainly due to other associated problems. The overall quantitative comparison did indicate the positive impact of tile drainage systems in terms of improving the cropping intensities at all four study sites. Therefore, it is justified to say that the objectives have been achieved by these projects in terms of improving the cropping intensities in irrigated areas.

1. INTRODUCTION

Pakistan's economy is mainly dependent on agriculture. More than 68% population of Pakistan is directly or indirectly supported through this sector. Almost 80% of the agricultural production comes from irrigated agriculture and the remaining 20% from the uncommanded rain fed areas (Chaudhry et al., 2002; Azhar et al., 2004a). After the advent of canal irrigation without adequate drainage facilities, agricultural lands of Pakistan have suffered from the twin menace of waterlogging and salinity. In early sixty's when this situation caused threat to crop production and natural environment of country, the GOP put a great emphasis to control this problem. Till the year 2003, the GOP has made tremendous efforts to mitigate the impact of waterlogging and salinity. The subsurface pipe drainage technology was introduced in Pakistan about three decades ago to control waterlogging and salinity. To-date, eight drainage projects have been completed in various provinces of the Pakistan. However, no systematic effort has been made to analyse the data of these systems in terms of *"improvement evaluation"*. Keeping in view the huge investments incurred and the benefits attached with those projects, there is a great need to evaluate the performance of those systems and to suggest improvements for future drainage systems. As such, a study was conducted by IWASRI under National Drainage Programme (NDP). Under this study, four subsurface pipe (tile) drainage projects namely; Mardan SCARP Project (MSP), Fourth Drainage Project, Faisalabad (FDP), Chashma Command Area Development Project (CCADP) and Mirpurkhas Tile Drainage Project (MKDP) were assessed in terms of their impact on improvement of irrigated agriculture conditions. For this purpose, various performance indicators were investigated. However, in this paper the analysis of only one performance indicator viz. cropping intensity has been presented.

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2. DESCRIPTION OF STUDY AREA

In Pakistan, to-date eight pipe drainage projects have been installed. As stated earlier, for this study only four sites viz. MSP (NWFP), FDP (Punjab), CCADP (NWFP) and MKDP (Sindh) have been selected. These project sites have been selected based on their wide range of geohydrological and climatic conditions. In addition, these sites cover a range of old as well as most recently installed pipe drainage systems in different provinces of Pakistan. This range of selection would facilitate to evaluate the performance of pipe drainage systems that were designed using old and new technology. The salient features of four selected project sites are shown in Table-1. For details regarding each of these project-sites, the reader is referred to Azhar et al., (2004b).

Table- 1 Salient Features of Selected Pipe Drainage Projects

DESCRIPTION	MSP	FDP	CCADP	MKDP
Gross area	50,020 ha	52,609 ha.	63,509 ha	-
Tile drainage area	29,542 ha	30,351 ha.	60,936 ha	24,281 ha
Installation. Period	1983–92	1988–94	1984-94	1994–97
Mean annual rainfall	542 mm	356 mm	250 mm	150 mm
Design WT depth	140 cm	122 cm	140 cm	122 cm
Target Crop. intensity	180%		150%	-
Executive agency	WAPDA	WAPDA	WAPDA	WAPDA
Consultancy	Harza NESPAK	USBR	Harza NESPAK	Mott. Macdonald
No. of units/sumps	385	79	65	52
Area per unit/sump	100-300 ac	900-1000 ac	400-900 ac	-
Type of outlet	Gravity	Pumped	Pumped	Pumped
Total costs (PC-I)	Rs 673×10^6 (1981)	Rs 1127×10^6 (1988)	Rs 1127.800 million	Rs 2473 million

(After Azhar et al., 2004b)

3. METHODOLOGY

As stated earlier, in this study only one impact/performance indicator namely cropping intensity has been analysed. For this analysis, relevant data were collected from various sources such as WAPDA, Provincial Irrigation & Power Department and through farmers' interviews conducted by IWASRI Consultants. The required data were collected for three stages i.e. *before*, *during* and *after* the installation of drainage system. The collected data were first screened for their integrity, and then analysed in various ways to assess the success of drainage projects based on above stated performance indicator. In this study, for quantitative comparison between pre & post-project conditions, the numerical value of above impact indicator (hereafter referred to as *impact parameter*) has been used. Hence, the *impact parameter* used was the targeted value of that impact indicator, if specified/documented for particular site (e.g. targeted cropping intensity). In case, the targeted value was not documented, the pre-project value of that impact indicator was used as the *base value*.

4. RESULTS AND DISCUSSIONS

In general, the cropping intensity is expected to increase with the installation of pipe drainage system. With regards to the *cropping intensity parameter*, it is worth mentioning that for quantitative comparison no targeted value of this impact indicator was available for FDP and MKDP study sites. For MSP and CCADP study sites, the post-project targeted value of total cropping intensity parameter was 180% (Smedema et al., 1990) and 150% (Harza, 1995). Hence, at FDP & MKDP the quantitative comparison was made based on the change in pre and post-project conditions at respective project site. The impact on cropping intensities of four study sites is discussed as below:

4.1 MSP Area

The year-wise cropping intensities of MSP area for the period 1979 to 2003 as available from the Provincial Irrigation & Power Department (PID) are graphically shown in Figure 1. In this figure, following the implementation of drainage system (i.e. 1991-92 year), a progressive increase in total cropping intensity is shown as compared with the pre-project (i.e. 1981-82 year) conditions.

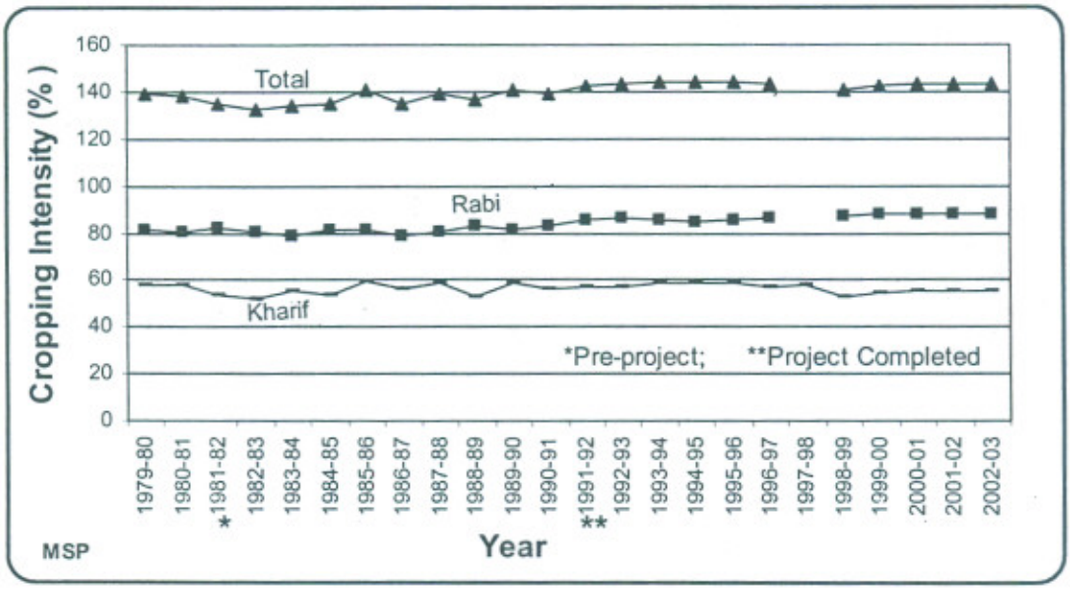


Figure 1 Cropping Intensities during 1979-80 to 2002-03 at MSP

As can be observed, the total cropping intensity during pre-project (1981-82) year was 135%, which increased to 143% during the post-project (2002-03) year, showing a net increase of 8%. It is important to note that in Figure 1, the increase is not significant, however, the information obtained through farmers' interviews showed a significant increase in the cropping intensity of this area as compared with the pre-project conditions. Based on farmer's interviews pre & post-project cropping intensities at MSP are shown in Figure 2. An increase of 66% in total cropping intensity (i.e. from 164% to 230%) is clearly shown in this figure.

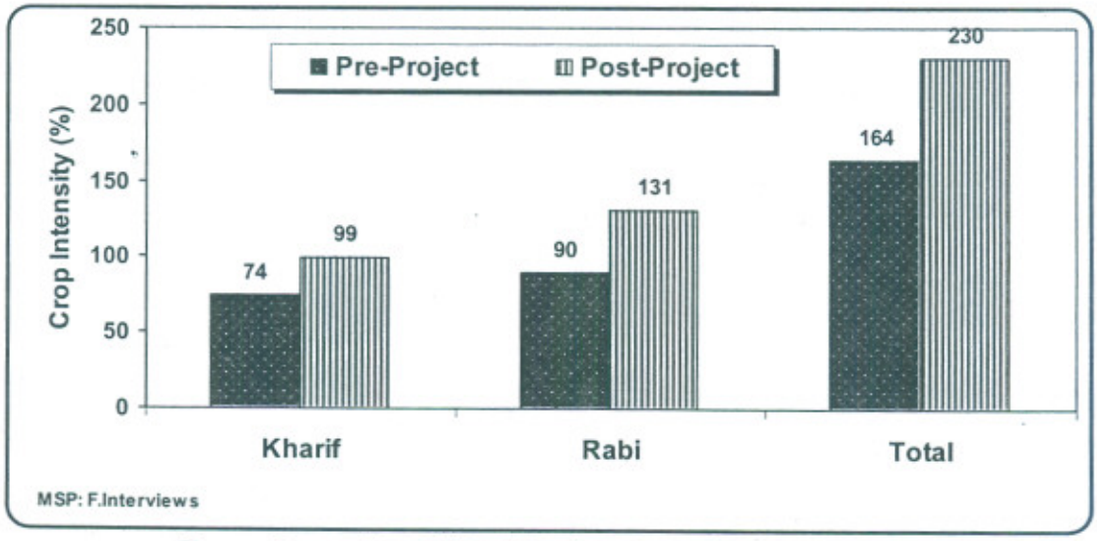


Figure 2 Pre & Post-Project Cropping Intensities at MSP

As stated earlier, for quantitative comparison of total cropping intensity at MSP area, the post-project targeted value of 180% was documented (Smedema et al., 1990). Hence, at this site the quantitative comparison was made based on the change in pre & post-project conditions as well as against the target value of 180%. Based on the above analysis of data, the comparison of pre & post project conditions revealed that there was a simple increase of 66% (i.e. 230-164) in total cropping intensity of this area. Also, the achieved post-project value of 230% was greater than the target value of 180%. This shows the positive impact of drainage system installation in terms of cropping intensity improvement at MSP area.

4.2 FDP Area

The year-wise cropping intensities of FDP area as available from PID for the period of 1986 to 2000 are graphically shown in Figure 3. As can be observed, during pre-project (1986-87) year, annual cropping intensity was 144% (Kharif 59%, Rabi 85%). For this area, the overall cropping intensity was envisaged not likely to decrease (WAPDA, 2001). Figure 3 revealed that cropping intensities have gone-up to 164% during post-project (1999-00) year (showing a net increase of 20%), despite the fact that water shortage became more acute due to below normal rains during the years 1998-2000 as reported in WAPDA (2001). It was reported that shortage of crop water requirement was made up with the help of pumpage from private tubewells installed in that area.

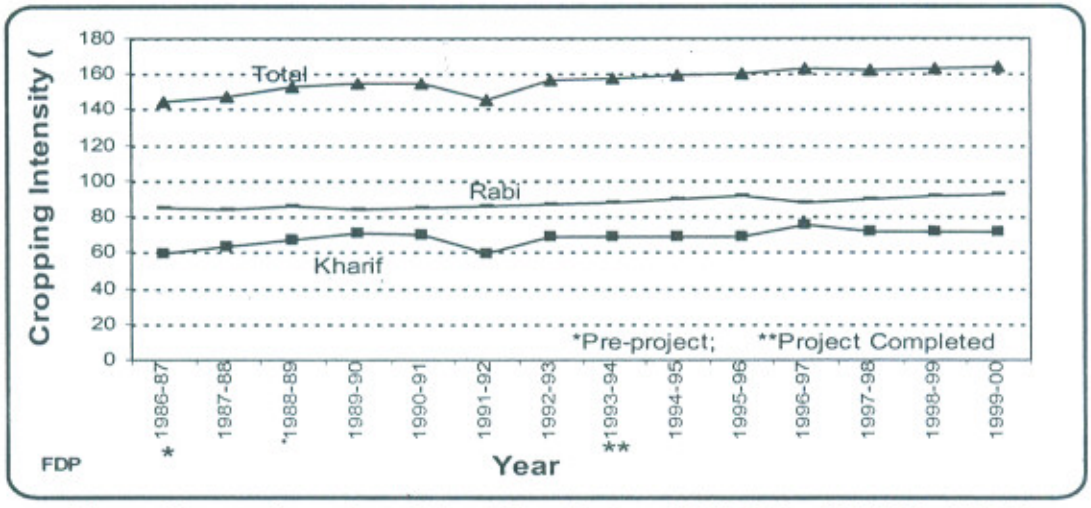


Figure 3 Cropping Intensities during 1986-87 to 1999-00 at FDP

Based on the farmer's interviews, pre and post-project (i.e. 2003-04 year) cropping intensities at FDP are graphically shown in Figure 4. An increase of 55% in total cropping intensity (i.e. from 102% to 157%) is clearly indicated in this figure.

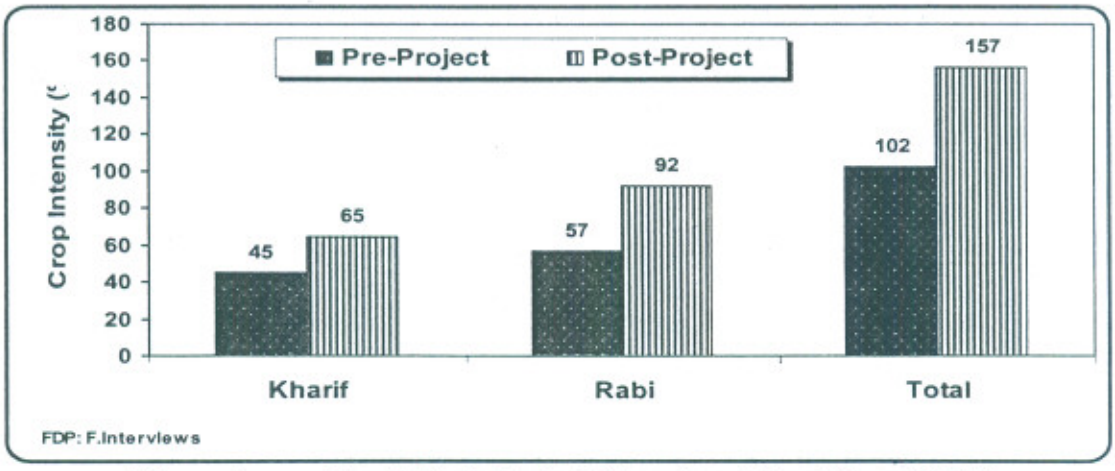


Figure 4 Pre & Post-Project Cropping Intensities at FDP

4.3 CCADP Area

The year-wise cropping intensities as available from the provincial Irrigation & Power Department of CCADP area are graphically shown in Figure 5. As stated earlier, the target cro*pping intensity* for CCADP was 150%. In Figure 5, following the implementation of drainage system (i.e. 1994-95 year), a progressive increase in total cropping intensity is clearly shown as compared with the pre-project (i.e. 1983-84 year) conditions. As can be observed, the total cropping intensity during pre-project (1983) year was 126%, which increased to 162% during the post-project (2003) year, showing a net increase of 36%. A slight decrease from 170% (during 2001-02) to 162% (during 2002-03) was mainly due to the shortage of irrigation supplies in the area, as told by the farmers. However, as compared with the targeted cropping intensity value of 150%, the total cropping intensity of 162% during post-project (2003) year, clearly shows that the target was achieved. Based on farmer's interviews pre & post-project cropping intensities at CCADP are shown in Figure 6. An increase of 65% in total cropping intensity (i.e. from 97% to 162%) is clearly shown in this figure.

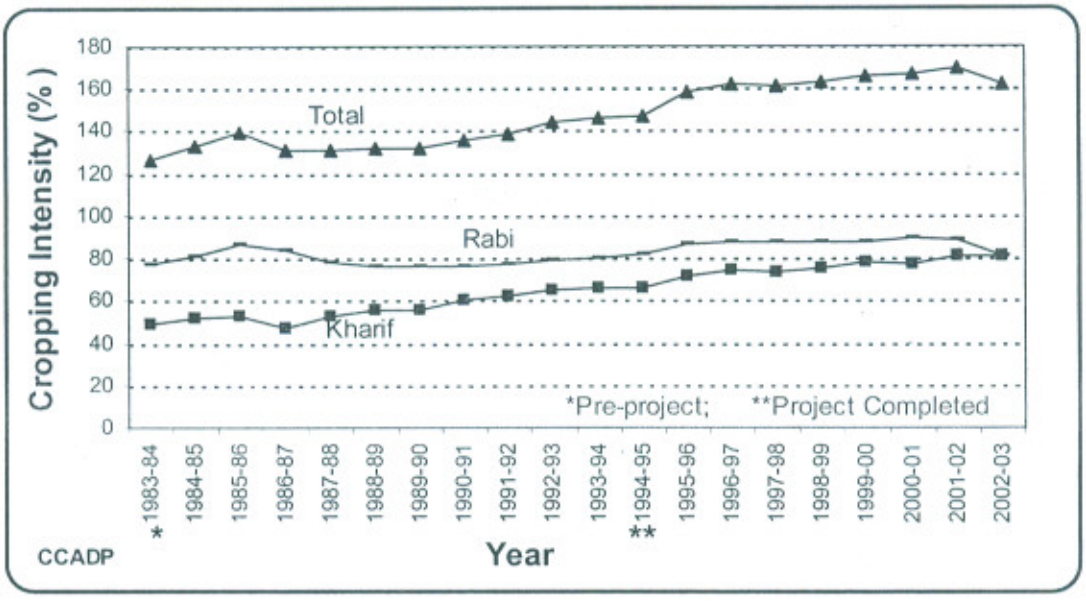


Figure 5 Cropping Intensities during 1983-84 to 2002-03 at CCADP

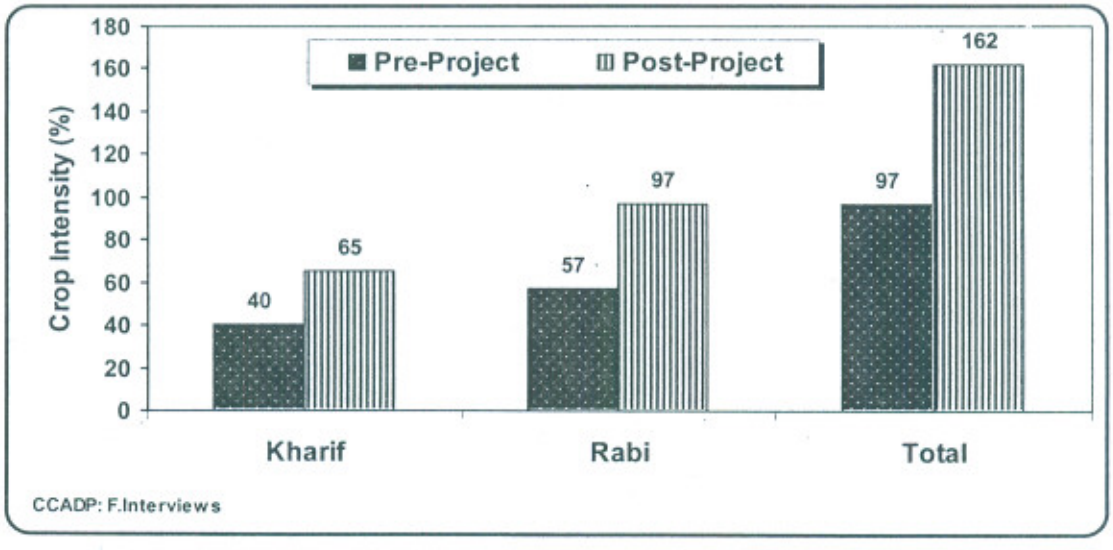


Figure 6 Pre & Post-Project Cropping Intensities at CCADP

4.4 MKDP Area

Based on farmer's interview at MKDP, it was revealed that during the pre-project (i.e. 1993-94) year, annual cropping intensity was 128% (Kharif 64%, Rabi 64%). The overall cropping intensity was envisaged to increase, which was achieved (Kharif 76%, Rabi 76%, Total 152%) during the post project (i.e. 2002-03) year despite the fact that water shortage became more acute due to below normal rains during these years. The pre & post-project cropping intensities at MKDP are graphically shown in Figure 7. An increase of 24% in total cropping intensity is clearly shown in this figure.

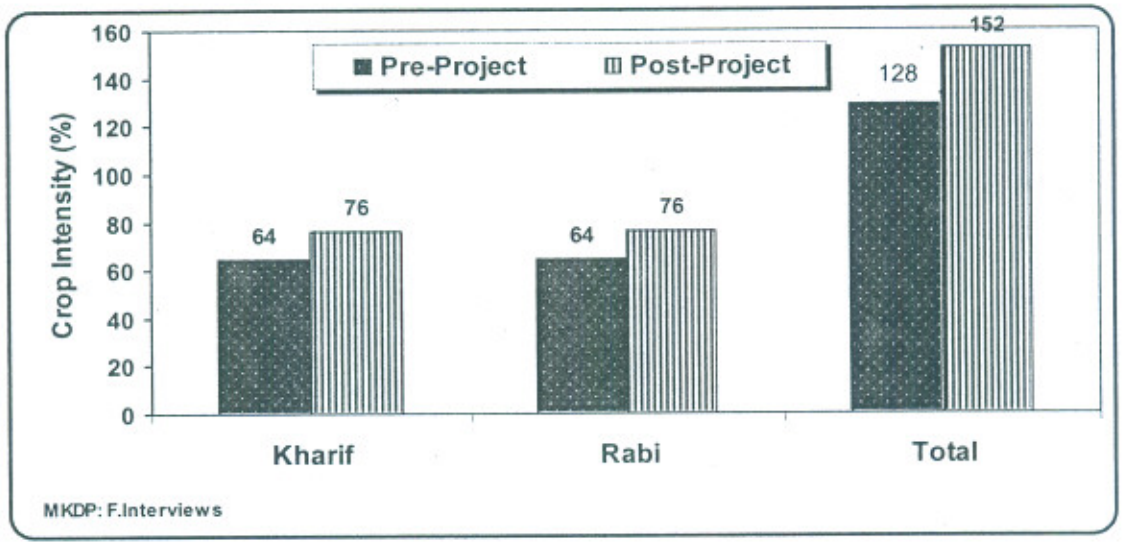


Figure 7 Pre & Post-Project Cropping Intensities at MKDP

4.5 Overall Comparison

As stated earlier, for quantitative comparison no target value of this impact indicator was available for FDP & MKDP study sites. For CCADP & MSP sites, the target value was documented as 150% and 180%. Hence, at FDP & MKDP the quantitative comparison was made based on the change in pre and post-project conditions at respective project site. A summary of total cropping intensities at four study sites is given in Table-2. The perusal of Table-2 revealed that at MSP, the target value of annual cropping intensity (180%) was not only achieved but it showed an extra upward trend up to 230%. Similarly, at CCADP an upward trend of 162% was observed against the target value of 150%. The quantitative comparison of *simple increase* (i.e. pre & post project difference) in cropping intensities at four study sites (Table-2) is graphically shown in Figure 8. As can be observed, maximum (significant) increase in the annual cropping intensity was at MSP (66%) and CCADP (65%) sites, whereas FDP (55%) was second in order. The least increase of 24% was at MKDP area. This shows the positive impact of drainage system installation in terms of cropping intensity improvement in those project areas.

The *percent change/improvement* in cropping intensity (Table-2) based on pre-project conditions for four study sites is shown in Figure 9. Based on this figure, the four study sites in terms of *percent improvement* in annual cropping intensity in the order from maximum to minimum can be ranked/listed as: CCADP (67%) > FDP (54%) >MSP (40%) >MKDP (19%). This order of improvement indicates how various project sites were benefited from the drainage activity in those areas. As investigated, the main reasons for slow benefits at FDP & MKDP study sites were the limited financial resources available with farmers to reclaim/restore the fertility of waste lands, and shortage of irrigation supplies during the post-construction period to leach down the excess salts. Another reason was the poor operation and maintenance (O&M) of the drainage sumps at those study sites. This aspect revealed that efforts put to alleviate the

problems of waterlogging & salinity through implementation of pipe (tile) drainage systems had not been up to the expectations mainly due to other associated problems. However, the overall quantitative comparison did indicate the positive impact of tile drainage systems in terms of improving the cropping intensities at all four study areas.

Table-2 Comparison of Annual Cropping Intensity at Four Study Sites

Study Site	Pre-Project (%) (1)	Post-Project (%) (2)	Simple Increase (%) (3)	Percent Change/ Improvement (%) (4)
MSP	164	230	66	40
FDP	102	157	55	54
CCADP	97	162	65	67
MKDP	128	152	24	19

Col(3) = {Col (2) - Col (1)}; Col(4) =100{Col (2) - Col (1)}/Col (1)*

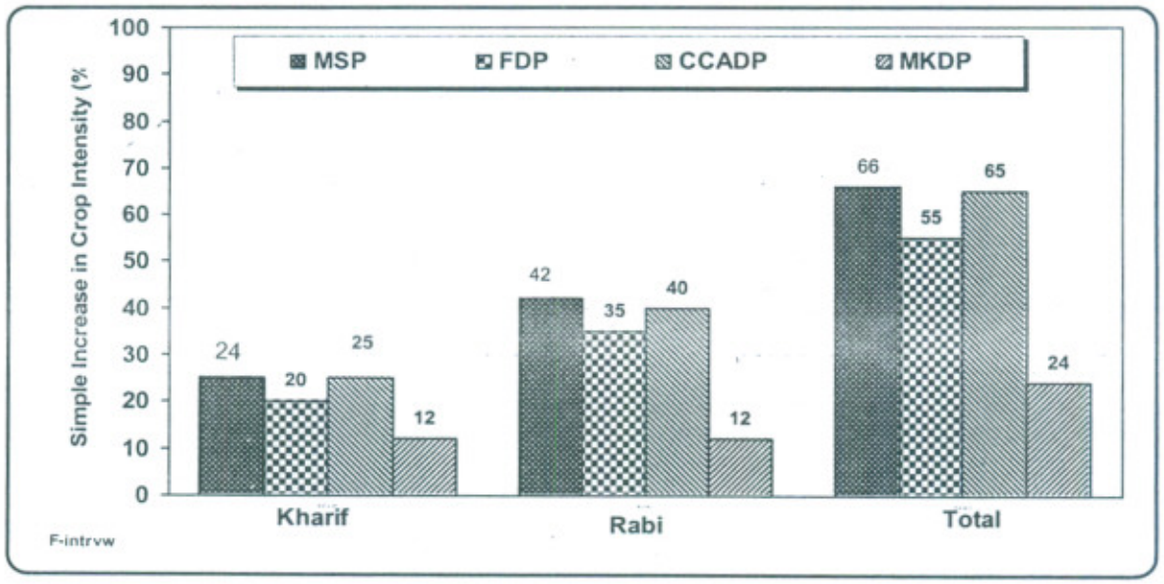


Figure 8 Simple Increase in Cropping Intensity at Four Study Sites

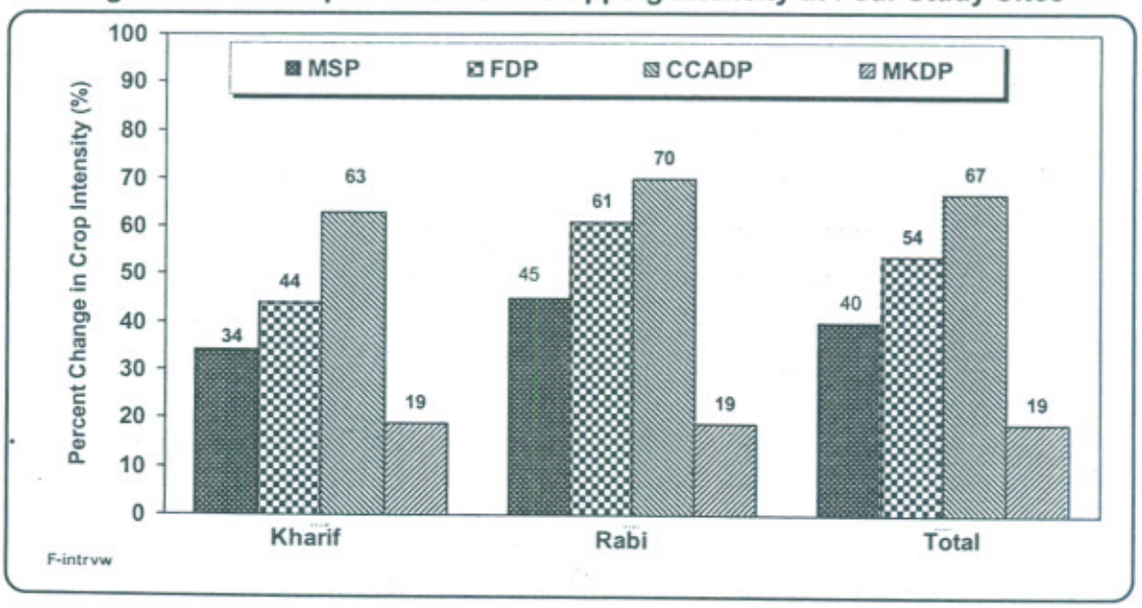


Figure 9 Percent Change/Improvement in Cropping Intensity at Four Study Sites

A comparison of *simple increase* in cropping intensity obtained from two different sources namely Provincial Irrigation Department (PID) and Farmers' Interviews conducted by IWASRI consultants for four project sites is graphically shown in Figure 10. As can be observed, there exists a significant difference in both the values. It shows the ambiguity inherent to data collection from various sources which must be carefully noted before using a data set for specific purposes. The PID data figures are sometimes socially & politically influenced, hence, in present study the farmer's interviews were given more importance than PID data values. Nevertheless, the historical trends of cropping intensities have been plotted using the PID data sets.

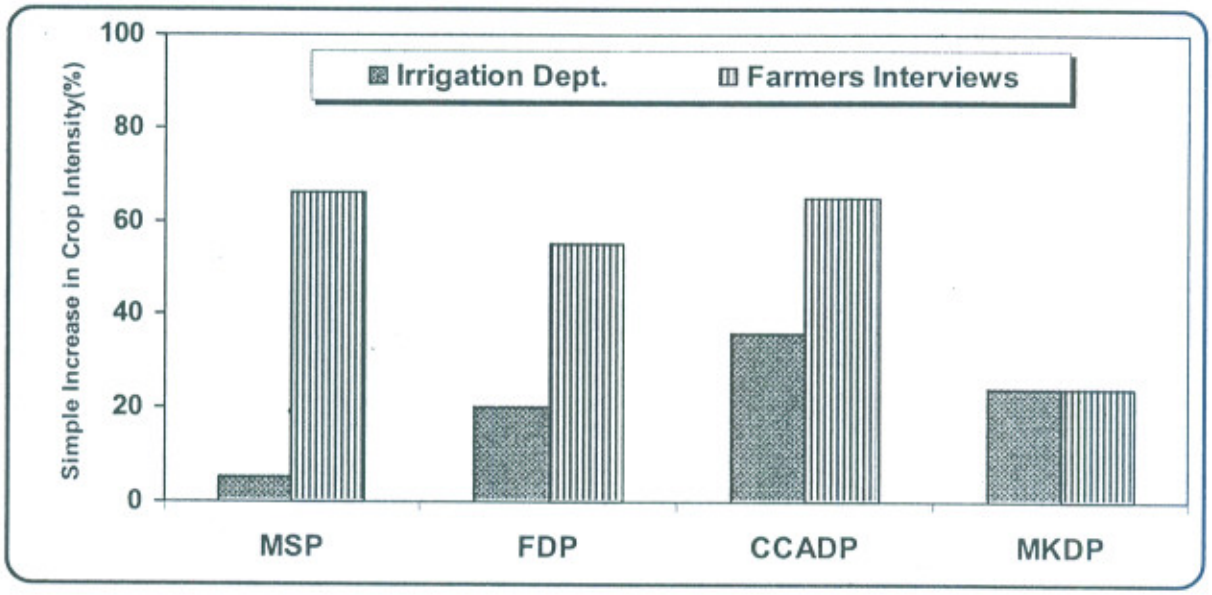


Figure 10 Cropping Intensities Obtained from PID and Through Farmer's Interviews

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the analysis of this study, following conclusions were drawn:

(i). The perusal of data analysis revealed that the objectives of drainage systems installation have been achieved in terms of improving the cropping intensities at all four study sites.

(ii). At MSP, the target value of annual cropping intensity (180%) was not only achieved but it also showed an extra upward trend up to 230%. Similarly at CCADP, an upward trend of 162% was observed against the target value of 150%.

(iii). The quantitative comparison of *simple increase* (i.e. pre & post-project difference) in cropping intensities indicated that maximum (significant) increases were at MSP (66%) and CCADP (65%) sites, whereas FDP (55%) was second in order. The least increase of 24% was at MKDP area. This shows the positive impact of drainage system installation in terms of cropping intensity improvements in those areas.

(iv). The four study sites in terms of *percent change/improvement* in annual cropping intensity in the order from maximum to minimum can be ranked/listed as: CCADP (67%) > FDP (54%) >MSP (40%) >MKDP (19%). This order of improvement indicates how various project sites were benefited from the drainage activity in those areas.

(v). As investigated, the main reasons for slow benefits at FDP and MKDP study sites were the limited financial resources available with farmers to reclaim/restore the fertility of

waste lands, and the shortage of irrigation supplies during the post-construction period to leach down the excess salts. Another reason was the poor Operation and Maintenance (O & M) of the drainage sumps at those sites. This aspect revealed that efforts put to alleviate the problems of waterlogging & salinity through implementation of pipe drainage systems had not been up to the expectations mainly due to other associated problems. However, the overall quantitative comparison did indicate the positive impact of tile drainage systems in terms of improving the cropping intensities at all four study sites.

(vi). Comparison of cropping intensities obtained from two different sources namely Provincial Irrigation Department (PID) and Farmers' Interviews showed that there existed a significant difference in both the values. This aspect indicates the inherent ambiguity in data collection from different sources which must be carefully noted before using a data set for specific purposes.

(vii). Although, the objectives of drainage systems installation have been achieved by these projects in terms of improving the cropping intensities, the benefits can further be enhanced by improving the operation and maintenance of those systems.

5.2 Recommendations

- There should be a regular and systematic mechanism of performance evaluation at national level, and it must be independent of project authorities.

- As a result of drainage system operation, irrigation requirements of crops are significantly increased due to reduced sub-irrigation. Hence, the post-construction irrigation supplies should be carefully reviewed and improved accordingly.

- In order to get the maximum benefits from the installed drainage systems, farmers should be facilitated with easy credit facilities.

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SURFACE HARDENING OF MILD STEEL BY PACK CHROMIZING

By

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ABSTRACT

A pack chromizing technique has been successfully applied to mild steel which resulted in significant improvement in surface hardness which is useful in improving the wear resistance. Chromizing mixtures using Chromite ore, Ferrochrome and chromium powder with NH_4Cl were used. The hardness of the surface of the specimens increased from 63.5 VPN to 246 VPN when chromized in the Chromite ore - NH_4Cl mixture which is the maximum as compared to the specimens chromized in other two mixtures.

INTRODUCTION

Diffusion chromizing is one of the important surface hardening methods used to develop wear resistance in a number of iron carbon alloys. At present diffusion chromizing of alloys is possible by four methods. Solid, vapour, gas and liquid phase chromizing. The solid method involves placing the diffusing metal in powder form in contact with the surface of the alloys to be surface hardened. Diffusion saturation of refractory metals like molybdenum, tungsten, niobium in iron and nickal is conducted using this method. The vapour phase method can be done by two techniques. In the first case, evaporation up metal takes place in the reaction zone in the immediate vicinity of the area of contact of powder of the evaporating metal with the metal substrate surface. In the second, this evaporation takes place away from the metal substrate surface. The vapour phase method, therefore, is used for diffusion coatings of alloys by metals with a higher vapour pressure as well as a low vapour pressure. Gas method is based on the interaction of the gaseous phase, which contains the diffusing element in the form of its chemical component with the substrate metal surface. Different halides of diffusing elements serve as the active gaseous phase. In liquid method the active phase taking part in the transport of diffusing element to the metal substrate is either a molten salt containing the diffusing metal or a melt of the metal itself. In the first case, the metal- metal interface a chemical reaction takes place because of which the process of saturation is possible. In the second case, diffusion saturation occurs directly from the molten metal.

There are a number of industrial applications of diffusion chromizing. These include exhaust systems of engines, gas turbine blades, nozzles and atomizers operating under conditions of corrosion, diesel engine valves, grates of gas stores, atomizers for fuel oils and parts of heat exchangers. Despite being a very useful surface hardening technique throughout the world, diffusion chromizing has not been adapted by industry in Pakistan. In the present work, diffusion chromizing of mild steel is carried out by pack chromizing technique in order to improve its surface hardness, which is a simple method and could be utilized by the local industry.

EXPERIMENTAL WORK

Low carbon ferrochromium lumps containing 0.05% C, 65-72% Cr and 35-28% Fe were used. It might be mentioned that ferrochromium is commercially available in two grades.

Low carbon ferrochromium containing 0.05-1.0%C

High carbon ferrochromium containing 6-7%C

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Low carbon ferrochromium having carbon content below 1.0% is desirable, as the high carbon content reduce the diffusivity of Cr in the substrate metal. Carbon have relatively high affinity for combining with Cr at the chromizing temperatures.

Ferrochromium lumps are difficult to be crushed into powder, the lumps were, therefore, heated to about 1000 °C in a furnace and then quenched in water. By the above treatment, the lumps became and were made into the powder easily.

Powder consisting of 50% (by weight) of ferrochromium, 43% (by wight) of fire clay & 7% (by weight) for NH_4Cl was used to prepare the chromizing mixture as it is fairly effective & cheap and can be easily regenerated. Before mixing, the ammonium chloride was dried in a frying pan at about 150 C°. After cooling it was ground and mixed with the ferrochromium powder in the required ratio. All the three components of the mixture were thoroughly mixed by hand.

The specimens were turned and cut from mild steel bar of 13mm dia. After cutting, the specimens were cleaned with emery paper so that the rust and scale was removed. All the specimens were dipped in boiling NaOH solution and rinsed with tap water to remove the traces of oil. The specimens were then dried and made ready for packing.

Initially a layer of 25mm mixture was spread on the bottom of the container. The specimens to be chromized were placed on this layer in such a manner that they were separated by 15mm from each other and 20mm from walls. The specimens were covered by a 10mm layer of the mixture. Again the specimens were placed on this layer and covered by the chromizing mixture and this layer was leveled and lightly rammed by a wooden hammer. Then lid was placed on the container and was packed by fireclay. After packing the specimens in the container, the container was placed in the furnace at temperature of 1000 C°. The specimens were heated at this temperature for 8 hours. After 8 hours the container was unloaded and cooled down to room temperature. The specimens were removed, scraped with wood to remove the clinging particles and washed in clean water. Chromizing of mild steel specimens was also carried out using chromium powder and chromite ore in the mixtures.

After Chromizing, the specimens were prepared for the hardness determination by Vickers Hardness testing machine with a 5 kg load.

RESULTS & DISCUSSION

The results obtained from the pack chromizing experiments using all three mixtures are given in Table 1 and are shown graphically in Figures 1 and 2.

Table : 1

Chromizing mixture	Core hardness (VPN) (Unchromized)	Case hardness (VPN) Chromized	% age increase in hardness
Chromite Ore	63.5	220	246%
Ferrochrome	63.5	171	169%
Chromium Power	63.5	246	287%

Table 1 and Figure 1 is for mild steel specimens which were chromized in different chromizing mixtures. This table shows the increase in hardness of the mild steel after chromizing. It may be seen from Table 1 and Figure 1 that the mild steel specimens chromized in a chromizing mixture of Chromite ore and NH_4Cl, hardness of the case is reached to 220 VPN. In case of the specimens, chromized in the mixtures of Ferrochrome and NH_4Cl the hardness of the case reaches to 171VPN where as the hardness obtained from the specimens chromized in chromium powder and NH_4Cl mixture, is 246 VPN. It may be seen that the

hardness of the mild steel specimens chromized in chromium powder, is highest than the specimens chromized in chromite ore and Ferrochromium.

On comparing the hardness of the case and the core as given in Table 1 and Figure 2, it may be seen that chromizing in mixture of chromium powder the % age increase in hardness is 287% where as by Chromite ore and Ferrochromium, the % age increase in hardness is 246% and 169% respectively.

CONCLUSIONS

1. The pack chromizing technique presented in this work could be successfully applied to mild steels for increasing the surface hardness to improve the wear resistance.

2. Various chromizing mixtures such as Chromite ore, Ferrochrome and Chromium powder with NH_4Cl could be used in this technique.

3. Chromizing in the Chromium powder and NH_4Cl mixture gives a significant increase in the hardness of the case.

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