51st YEAR OF PUBLICATION

Engineering News

A Quarterly Journal of the Pakistan Engineering Congress
Vol. 43 January - March 2010 No. 13

ON OTHER PAGES

IN THIS ISSUE

Message from Engr. Husnain Ahmad President Pakistan Engineering Congress 2

NEWS

☆ Address of Welcome by Engr. Husnain Ahmad President Pakistan Engineering Congress on World Water-Day March, 2010 3

☆ Address by the Chief Guest Mr. Shakil Durrani Chairman WAPDA on World Water-Day March, 2010 11

☆ World Water-Day - March, 2010 - A Report 14

☆ Welcome to New Members 21

TECHNICAL PAPERS

☆ Use of Saline Groundwater for Crop Production on Salt Affected Soil 22
-Aziz Ahmad Malik, Khalid Mahmood Subhani and M. A. Shad

☆ Water Quality Challenges and Opportunities 28
-Zia Mustafa

☆ Construction Dispute Resolution : A Changing Landscape 33
-Ir. Chong Thaw Sing

☆ Remediation of Contaminated Land with Solidification / Stabilisation Technology 37
-Ahsan Iqbal Bela

☆ Lahore Water Supply System and Monitoring of Drinking Water 40
-Zainab Abbas Soharwardi and Dr. Javed Iqbal

☆ Noise Pollution 48
-Muhammad Asif

☆ List of Proceedings of the Institution of Civil Engineers UK Volume 163, 2010 55

EDITOR
Engr. Prof. Zia-ud-Din Mian

PUBLISHED BY
Pakistan Engineering Congress
4TH FLOOR, PAKISTAN ENGINEERING CONGRESS BUILDING, 97-A / D-1, LIBERTY MARKET, GULBERG III
LAHORE 54660
Ph: 35784237-35784238 Fax: 35784236

FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country.

World Water Day

March 2010

World Water Day

March 2010

CELEBRATED BY

Pakistan Engineering Congress

PAKISTAN ENGINEERING CONGRESS
4TH FLOOR, PAKISTAN ENGINEERING CONGRESS BUILDING,
97-A / D-1, LIBERTY MARKET, GULBERG III, LAHORE 54660
(NEAR LIBERTY ROUNDABOUT)
PHONE : 35784238, 35784235 FAX : 35784236
Web-site : www.pecongress.org.pk
E.mail : info@pecongress.org.pk

50th YEAR OF PUBLICATION

Engineering News

A Quarterly Journal of the Pakistan Engineering Congress
Vol. 43 April - June 2009 No. 10

ON OTHER PAGES

IN THIS ISSUE

Message from Engr. Husnain Ahmad President Pakistan Engineering Congress 2

NEWS

☆ Visit of Team of Pakistan Engineering Congress to Mangla Dam Raising Project 3

☆ World Environment Day - Report 13

☆ Address of Welcome by Engr. Husnain Ahmad President Pakistan Engineering Congress 17

☆ Address by the Chief Guest Mian Amer Mahmood District Nazim Lahore 22

☆ Bio-Diesel Production Jatropha Plantation Project in Pipeline with Support of Korea 24

☆ Welcome to New Members 26

☆ Proceedings of the Institution of Civil Engineers UK 2008 - 2009 Available at PEC Library 27

TECHNICAL PAPERS

☆ Characterization of Grade 316 Stainless Steel as a Biomaterial by Electrochemical Analysis 45
-M. T. Z. Butt, F. Riaz, F. Hussain and K. M. Deen

☆ Low Income Housing in a Rapidly Urbanizing Pakistan
-Prof. Dr. S. Shabih-ul-Hassan Zaidi 51

☆ Evaluation Methodology for Transnational Infrastructure Gas Projects : A Case Study of Pakistan 58
-Sidra Nisar Malik and Nasir Hayat

☆ Protect Environment by Re-duce, Re-use & Recycling (3R's) 75
-Asif Masood

EDITOR
Engr. Prof. Zia-ud-Din Mian

PUBLISHED BY
Pakistan Engineering Congress
4TH FLOOR, PAKISTAN ENGINEERING CONGRESS BUILDING, 97-A / D-1, LIBERTY MARKET, GULBERG III
LAHORE 54660
Ph: 35784237-35784238 Fax: 35784236

FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country.

50th YEAR OF PUBLICATION

Engineering News

A Quarterly Journal of the Pakistan Engineering Congress
Vol. 43 July - September 2009 No. 11

ON OTHER PAGES

IN THIS ISSUE

Message from Engr. Husnain Ahmad President Pakistan Engineering Congress 2

NEWS

☆ Address of Welcome by Engr. Husnain Ahmad President Pakistan Engineering Congress on Symposium on Genesis of Power Crisis and Its Management in Pakistan 3

☆ Symposium on Genesis of Power Crisis and its Management in Pakistan - A Report 9

☆ National Development Consultants (Pvt) Ltd. Awarded Consultancy Services in Yemen 17

☆ The World's Longest Sea Bridge 19

☆ Latest Addresses and Contact Numbers of PEC Members - Required 20

☆ Welcome to New Members 23

TECHNICAL PAPERS

☆ Modelling the Seepage from Chashma Jhelum Link Canal and Rehabilitation of the Waterlogged Areas 24
-Engr. Muhammad Basharat and Engr. Muhammad Saeed

☆ Development and Characterization of Polyester Based Hybrid Composites with E-Glass and S-Glass Reinforcements 39
-Dr. Khalid Mahmood Ghauri, Ubaid-ur-Rehman Ghori, Dr. Liaqat Ali and Dr. Gul Hameed Awan

☆ Implementation of Pakistan Engineering Council Bidding and Contract Documents 45
-Engr. M. Mazhar-ul Islam

☆ Small Batch Size Sheet Metal Products Manufactured by Single Point Incremental Forming Process : Economic Analysis 52
-Syed Asad Raza Gardezi, Mushtaq Ahmad, Muhammad Aslam, Awais Ahmad Khan and Mohsin Ahmad Sadiq

☆ Water Pollution 59
-Asif Masood

EDITOR
Engr. Prof. Zia-ud-Din Mian

PUBLISHED BY
Pakistan Engineering Congress
4TH FLOOR, PAKISTAN ENGINEERING CONGRESS BUILDING, 97-A / D-1, LIBERTY MARKET, GULBERG III
LAHORE 54660
Ph: 35784237-35784238 Fax: 35784236

FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country.

50th YEAR OF PUBLICATION

Engineering News

A Quarterly Journal of the Pakistan Engineering Congress
Vol. 43 October - December 2009 No. 12

ON OTHER PAGES

IN THIS ISSUE

Message from Engr. Husnain Ahmad President Pakistan Engineering Congress 2

NEWS

☆ Participation of Congress Delegation in ICID Conference at Delhi, India 4
☆ Dead Sea Needs World Help to Stay Alive 10
☆ Climate Change : South Asia's 13
☆ Why is South Asia Vulnerable to Climate Change 15
☆ List of Missing Issues of Engineering News Journal 17
☆ Foreword by Engr. Ch. Ghulam Hussain Secretary (PEC) 18

TECHNICAL PAPERS

☆ Dam Engineering, its Practice and Potential in Pakistan 20
-Amjad Agha
☆ Construction Practices in Developing Countries 25
-Engr. Ch. Ghulam Hussain Secretary Pakistan Engineering Congress
☆ Managing Groundwater Pumping and Quality for Sustainable Irrigated Agriculture : A Perspective from Pakistan 31
-Dr. Asad Sarwar Qureshi and Khalid Mohtadullah
☆ Mineral Data Base Sources for Planning and Decision Making 39
-Prof. Dr. Tahir A. Gillani and Prof. Dr. Nazir A. Butt
☆ Characterization of Locally Produced Martensitic Stainless Steel Surgical Grade AISI 420A 48
-Muhammad Kamran, Faraz Hussain, Taqi Zahid Butt and Fahad Riaz
☆ Physico-Chemical Monitoring of Combined Industrial and Municipal Effluents in Paharang Drain, Faisalabad 52
-Muhammad Asim and Zahiruddin Khan
☆ Prospects of Rain Water Harvesting for Promoting Agriculture and Livestock Raising 60
-Talib Hussain, Dr. Allah Bakhsh Sufi and Khalid Javed
☆ Design and Fabrication of Silt Density Index Meter 66
-A. Mashiatullah, R. M. Qureshi and Maaz Khan
☆ Harvesting of Rain Water for Agriculture, Raising of Live Stock & Recharging Aquifer 70
-Engr. Abdul Rauf Chaudhry
☆ Assessment of Surface and Ground Water Quality at some Selected Sites in Rawalpindi City 75
-Lt. Col. Islam-ul-Haq (R),Harmain Rukh, Ghalib Husnain and Shahid Durez
☆ Vortex Type Silt Ejectors 95
-B. A. Shakir
☆ Electricity Through Garbage 105
-Dr. S. E. Benjamin and Asif Nishat
☆ Effect of Post Weld Heat Treatment on the Mechanical Properties and Microstructure of Carbon Steel Weld Using ER309L Filler Metal 111
-Liaqat Ali, Khalid Mahmood Ghauri, Gul Hameed Awan, Tariq Hussain and Ghulam Jalani
☆ List of Technical Papers 120

EDITOR
Engr. Prof. Zia-ud-Din Mian

PUBLISHED BY
Pakistan Engineering Congress
4TH FLOOR, PAKISTAN ENGINEERING CONGRESS BUILDING, 97-A / D-1, LIBERTY MARKET, GULBERG III
LAHORE 54660
Ph: 35784237-35784238 Fax: 35784236

FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country.

PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS UK VOLUME – 161 (2008) AVAILABLE AT PAKISTAN ENGINEERING CONGRESS LIBRARY

Sr. No. Main Topics

1 Construction Materials

! **Papers**

Evaluation of a warm-mix asphalt additive
K. Kanitpong, K. Nam, W. Martono and H. Bahia
Thermal cycling of wheat straw ash concrete
N. M. Al-Akhras, K. M. Al-Akhras and M. F. Attom
Water repellent influence on salt crystallisation in masonry
I. Ioannou and W. D. Hoff
Factors influencing the reactivity of quicklime
W. Gallala, M. E. Gaied, A. Tlili and M. Montacer
Influence of cement content on corrosion resistance
A. D. Medagoda Arachchige
Volume 161 ● Issue CM1 February 2008

2 Transport

! **Papers**

Brixton station congestion relief project, London
G. Biggam and H. Jayawardena
Probabilistic analysis of train-track vertical impact forces
J. Leong and M. H. Murray
Energy balance framework for appraising road projects
J. B. Odoki and R. Akena
Modelling of personality, attitude and risky driving
S. F. Kalyoncuoglu and M. Tigdemir
Volume 161 □ Issue TR1 February 2008

3 Geotechnical Engineering

! **Papers**

On-site characterisation of loessic deposits in Kent, UK
K. J. Northmore, I. Jefferson, P. D. Jackson, D. C. Entwisle, A. E. Milodowski, M. R. Raines, D. A. Gunn, D. I. Boardman, A. Zourmpakis, L. M. Nelder, C. D. F. Rogers, N. Dixon and I. J. Smalley
A practical design approach for piles with negative friction
H. G. Poulos
Loading tests on compacted soil, bottom-ash and lime layers
N. C. Consoli, A. Thome, M. Donato and J. Graham
Effective-stress analysis of berm-supported retaining walls
J. A. Smethurst and W. Powrie
CFA pile behaviour in very stiff lodgement till
E. R. Farrell and M. L. Lawler
Volume 161 ● Issue GE1 February 2008

4 Management Procurement and Law

! **Briefings**

Tracking site staff with wireless technology
J. Manning

Machine trial version

Culture and mindset-the NEC approach
J. Lofty
At the heart of society
D. Orr
Knowledge and information management for major projects
Institute of Civil Engineers ICT Panel

! **Papers**
UK civil engineering education in the twenty-first century
B. Barr
The impact of multiskilling on UK's construction manpower
O.A. Ejohwomu, D. G. Proverbs and P. Olomolaiye
Volume 161 ● Issue MP1 February 2008

5 Structures and Buildings

! **Papers**
Robustness of light steel frames and modular construction
R. M. Lawson, M. P. Byfield, S. O. Popo-Ola and P. J. Grubb
Achieving durable repaired concrete structures: a performance-based approach
S. Matthews and J. Morlidge
Neural network modelling of RC deep beam shear strength
K.-H. Yang, A. F. Ashour, J.-K. Song and E.-T. Lee
Discussion
Elastic analysis of ground-floor slabs under multiple loads
A. A. Abbas, M. N. Pavlovic and M. D. Kotsovos
Volume 161 ● Issue SB1 February 2008

6 Engineering and Computational Mechanics

! **Papers**
A new model for simulating cracks in cementitious composites
S. C. Hee and A. D. Jefferson
The known unknowns of hydraulic engineering
H. Chanson
Influence of anchor head on dynamic response of anchorages
A. Ivanovic and R. D. Neilson
Bend pressure drop experiments compared with Fluent
A. Kumar, D. R. Kaushal and U. Kumar
Volume 161 ● Issue EM1 March 2008

7 Geotechnical Engineering

! **Papers**
Bridge distress caused by approach embankment settlement
C. A. Jones, D. I. Stewart and C. J. Danilewicz
Sustainability of land remediation. Part1: overall analysis
M. J. Harbottle, A. Al-Tabbaa and C. W. Evans
Maintenance and monitoring of anchorages: guidelines
S. Littlejohn and D. Mothersille
Maintenance and monitoring of anchorages: case studies
S. Litteljohn and D. Mothersille
Discussion
Design charts for seismic analysis of single piles in clay
A. Tabesh and H. G. Poulos
Volume 161 ● Issue GE2 April 2008

pdfMachine trial version

8 Structures and Buildings

! **Papers**

T5A roof: the abutment first run study
W. Frankland and P. Hulme
Statistical analysis of structural vibrations due to crowd jumping loads
J. Sim, A. Blakeborough and M. S. Williams
Cyclic response of concrete-encased composite columns with low steel ratio
C. S. Shim, Y. S. Chung and J. H. Han
Effects of beam-column depth ratio on joint seismic behaviour
H. F. Wong and J. S. Kuang
Static design of elliptical hollow section end-connections
G. Martinez-Saucedo, J. A. Packer and X.-L Zhao

Volume 161 ● Issue SB2 April 2008

9 Water Management

! **Papers**

Stormwater sand filters in water-sensitive urban design
J. Kandasamy, S. Beecham and A. Dunphy
Water services regulation for the urban poor: Zambia
S. Kayaga and R. Franceys
Identifying risk factors of BOT for water supply projects
S. X. Zeng, T. W. Wan, C. M. Tam and D. Liu
Determining water surface elevation in tidle rivers by ANN
A. Adib
Critical flow over spillway profiles
O. Castro-Orgaz, J. V. Giraldez and J. L. Ayuso
Effect of the Froude number on assessment of the bridge afflux
G. Seckin, D. W. Knight, S. Atabay and N. Seckin
Experimental study of air demand in high head gated tunnels
K. Safavi, A. R. Zarrati and J. Attari

Volume 161 ● Issue WM2 April 2008

10 Construction Materials

! **Papers**

Sustainable concrete waste recycling
Y. Dosho
Using gypsiferous soil for embankments in hot desert areas
S. S. Razouki, D. K. Kuttah, O. A. Al-Damluji and I. H. Nashat
Effect of corrosion inhibitors on cement paste pore structure
L. Luo, G. Ye and G. De Schutter
Safe, high-tech and sustainable concrete construction
S. Desai

Volume 161 ● Issue CM2 May 2008

11 Ground Improvement

! **Papers**

Soil improvement by internally reinforced stone columns
T. Ayadat, A. M. Hanna and A. Hamitouche
Eccentricity effects on a footing supported by a stone column
M. Sadek and I. Shahrour
Modelling embankments reinforced with sand columns
M. Sathisbalamurugan and B. Muhunthan

Machine trial version

Subgrade modulus of geocell-reinforced sand foundations
S. K. Dash, P. D. T. Reddy and S. T. G. Raghukanth
Ground improvement by small-diameter timber piles
S. Ghosh, S. Mukherjee, R. B. Sahu, A. Ghosh and N. Som
Uplift of shallow foundations with cement-stabilised backfill
M. J. Rattley, B. M. Lehane, N. Consoli and D. J. Richards
Volume 161 ● Issue GI2 May 2008

12 Transport

! **Papers**
Environmental effects on development of pavement joint cracks
J.-H. Jeong
Skid resistance loss of plastic-grooved concrete roadways
S. W. Lee and B.-J. Chon
Traffic crashes at toll plazas in Hong Kong
N. N. Sze, S. C. Wong and W. F. Chan
Iberian rail: adding a new dimension to international travel
A. Lopez Pita, P. F. Teixeira, A. Bachiller, C. Casas-Esplugas and R. Insa
A transport policy toolkit for the West Midlands
T. van Vuren
Highway safety analysis using geographic information systems
M. Castro, L. Iglesias, R. Rodriguez-Solano and J. A. Sanchez
Volume 161 ● Issue TR2 May 2008

13 Waste and Resource Management

! **Papers**
Demolition waste: are we doing our best?
M. Bjerregaard
Resource flow analysis for sustainable construction: metrics for an integrated supply chain approach
J. Ravetz
Design and specification of tyre bales in construction
J. D. Simm, M. G. Winter and S. Waite
Constructed wetland as tertiary treatment for municipal wastewater
S. Ahmed, V. Popov and R. C. Trevedi
Resource recovery through catalytic cracking of waste plastics
P. A. Parikh and Y. C. Rotliwala
Volume 161 ● Issue WR2 May 2008

14 Engineering and Computational Mechanics

! **Papers**
How to treat continuous beams: A historical approach
P. H. Taylor
Zonal discharges and boundary shear in prismatic channels
D. W. Knight and X. Tang
Flexural buckling of laced column with crosswise lattice
A. G. Razdolsky
Simulation of self-centring fibre-reinforced concrete columns
W. K. Lee and S. L. Billington
Volume 161 ● Issue EM2 June 2008

pdfMachine trial version

15 Geotechnical Engineering

! **Papers**
Sustainability of land remediation. Part 2: impact assessment
M. J. Harbottle, A. Al-Tabbaa and C. W. Evans
Constant rate of displacement test on ultra-soft soil
M. W. Bo, K. S. Wong and V. Choa
Evaluation of innovative sprayed-concrete-lined tunnelling
B. D. Jones, A. H. Thomas, Y. S. Hsu and M. Hilar
Estimation of mean effective stress in clay soils
D. C. Shohet
Model specification to determine thermal conductivity of soils
B. G. Clarke, A. Agab and D. Nicholson
Discussion
Rock socket piles at Mall of the Emirates, Dubai
L. Alrifai
Volume 161 ● Issue GE3 June 2008

16 Structures and Buildings

! **Papers**
Calibration of resistance of shear connectors in troughs of profiled sheeting
R. P. Johnson
The continuous strength method
L. Gardner
Passive fire protection of concrete structures
G. A. Khoury
Seismic capacity evaluation of school building in Turkey
M. Inel
Stiffness identification of framed models under controlled damage
F. Garces, C. Genations, P. Garcia, M. Lafuente and A. Mebarki
Volume 161 ● Issue SB3 June 2008

17 Construction Materials

! **Papers**
Physical Properties of demolition waste material
I. Chidiroglou, A. K. Goodwin, E. Laycock and F. O'Flaherty
Recycling surfacing materials back into thin surfacing systems
J. C. Nicholls, I. Carswell, I. Widyatmoko, R. C. Elliot, J. Harris and R. Taylor
Durability of concretes containing natural pozzolan
M. Najimi, M. Jamshidi and A. Pourkhorshidi
Sulfate resistance of mortar containing simulated FGD waste
J. M. Khatib, P. S. Mangat and L. Wright
Strength of high-strength concrete heated to 250ºC
K. Srinivasa Rao, M. Potha Raju and P. S. N. Raju
Volume 161 ● Issue CM3 August 2008

18 Energy

! **Papers**
Decommissioning nuclear plants: experiences in Germany
R. Versemann
Biomass and waste co-firing in large-scale combustion systems
R. Marsh, J. Steer, E. Fesenko, V. Cleary, A. Rahman, T. Griffiths and K. Williams

pdfmachine trial version

Required improvements to primary energy in the IPCC scenarios
H. D. Lightfoot
Policy learning in UK renewable energy policy: a methodology
S. Murrall and I. Bailey
Discussion
Nuclear is not a stand-alone option
F. Starr and D. Andrews
Volume 161 ● Issue EN3 August 2008

19 Ground Improvement

! **Papers**
Predicted and measured loads using the coherent gravity method
R. J. Bathurst, A. Nernheim and T. M. Allen
Response of granular pile-anchors under compression
A. Srirama Rao, B. R. Phanikumar and K. Suresh
Electrochemical stabilisation for offshore model caissons
E. Mohamedelhassan, J. Q. Shang, M. A. Ismail and M. F. Randolph
Modelling and acoustic monitoring of grout propagation in sands
N. Saiyouri, L. Jason, O. Chupin and P. Y. Hicher
Seismic response evaluation of sites improved by deep mixing, Part I: Proposed approach
R. V. Siddharthan and A. Porbaha
Seismic response evaluation of sites improved by deep mixing, Part 2: Verification
R. V. Siddharthan and A. Porbaha
Volume 161 ● Issue GI3 August 2008

20 Geotechnical Engineering

! **Papers**
Axial resistance of CFA piles in Dublin Boulder Clay
K. Gavin, D. Cadogan and L. Twomey
Identifying low-fines soils not suited to NEF testing
A. Soroush, A.-H. Aminzadeh and P. T. Shourijeh
The ground: clients remain exposed to unnecessary risk
D. Egan
The Properties of Lias Clay for landfill liners
A. Binns, P. N. J. Robinson and C. S. Eccles
Using buttress walls to reduce excavation-induced movements
C.-Y. Gu, F.-C. Teng, R. B. Seed and I.-W. Wang
Discussion
Flow nets and textbooks
E. Bromhead
Volume 161 ● Issue GE4 August 2008

21 Structures and Buildings

! **Papers**
The seismic vulnerability of architectural heritage
A. Bernardini and S. Lagomarsino
Recent development in robustness and relation with risk
J. Agrawal and J. England
Risk, reliability and sustainability in the developing world
M. Sanchez-Silva and D. V. Rosowsky
Structural reliability and performance –based engineering
B. R. Ellingwood

Pdfmachine trial version

Treatment of risk and reliability in the Eurocodes
T. Vrouwenvelder
Reliability, responsibility and reality in structural engineering
D. A. Nethercot
Assessing and achieving structural safety
C. B. Brown, D. G. Elms and R. E. Melchers
Managing risks to structures
D. Blockley
Volume 161 ● Issue SB4 August 2008

22 Water Management

! **Papers**
The hydrological impact of low-flow alleviation measures
H. J. Clayton, S. E. Morris, N. R. McIntyre and M. Greaves
The evaluation of flood risk policy in the Netherlands
W. B. M. ten Brinke, B. A. Bannink and W. Ligtvoet
Trends in streamflow of the Euphrates basin, Turkey
K. Yenigun, V. Gumus and H. Bulut
Field verification of bed-mounted ADV meters
N. McIntyre and M. Marshall
Statistical analysis of structural failures of water pipes
A. Dehghan, K. J. McManus and E. F. Gad
Understanding blockage formation in combined sewer networks
S. Arthur, H. Crow and L. Pedezert
Volume 161 ● Issue WM4 August 2008

23 Maritime Engineering

! **Papers**
New port facilities at Punta Langosteira, Spain
F. J. Noya Arquero
Design and construction of a submarine outfall in Murcia, Spain
T. Hernandez, J. M. Gonzalez, A. V. Palazon and C. Conradi
Coastal erosion studies on the Capo Colonna cliff, Italy
L. Blois
Volume 161 ● Issue MA3 September 2008

24 Construction Materials

! **Papers**
Strength characteristics of hydraulic lime mortared brickwork
Z. Zhou, P. Walker and D. D'Ayala
Using slag for unfired-clay masonry-bricks
J. E. Oti, J. M. Kinuthia and J. Bai
Performance of a fibre-reinforced lightweight concrete panel
B. Arisoy and H.-C. Wu
Hybrid corrosion protection of chloride-contaminated concrete
G. K. Glass, A. C. Roberts and N. Davison
Durability of FRP-confined concrete
F. Micelli and J. J. Myers
Volume 161 ● Issue CM4 November 2008

PdfMachine trial version

25 Energy

! **Papers**

Is there an 'energy gap'?
C. Collins, R. Gross and P. Heptonstall
A bioenergy resources assessment for the south west of England
G. P. Hammond, M. C. McManus and W. G. Mezzullo
Ultra low *U*-value walls for low-carbon-dioxide homes
D. J. Bonnett, P. Smyth, J. Bonell and M. Vafea

Volume 161 ● Issue EN4 November 2008

26 Ground Improvement

! **Papers**

Prefabricated vertical drains: a simplified design procedure
I. Bellezza and R. Fentini
Reduction of smear effects around PVD using thermo-PVD
C. Pothiraksanon, J. Saowapakpiboon, D. T. Bergado and N. Y. Than
Experimental study on sand and gravel columns in clay
P. Andreou, W. Frikha, R. Frank, J. Canou, V. Papadopoulos and J.-C. Dupla
Field behaviour of granular pile-anchors in expansive soils
B. R. Phanikumar, A. Srirama Rao and K. Suresh
Behaviour of lime-slag-treated clay
R. James, A. H. M. Kamruzzaman, A. Haque and A. Wilkinson

Volume 161 ● Issue GI4 November 2008

27 Waste and Resource Management

! **Paper**

The application of LDAT to the HPM2 challenge
J. K. White
Landfill modelling challenge: HBM model predictions
J. McDougall
Review of responses to a landfill modeling challenge
R. P. Beaven
Assessment of the anaerobic biodegradation potential of MSW
L. K. Ivanova, D. J. Richards and D. J. Smallman

Volume 161 ● Issue WR4 November 2008

28 Maritime Engineering

! **Papers**

Assessing breaching risk in coastal gravel barriers
L. Hartley and N. Pontee
Extension to the port of Gijon, Spain
J. L. Diaz Rato, J. Moyano Retamero and M. de Miguel Riestra
Large breakwaters in deep water in northern Spain
P. Molinero Guillen

Volume 161 ● Issue MA4 December 2008

pdfMachine trial version

PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS UK VOLUME – 162 (2009) AVAILABLE AT PAKISTAN ENGINEERING CONGRESS LIBRARY

Sr. No. Main Topics

1 Ground Improvement

! **Papers**

Ground improvement techniques for railway embankments
A. Arulrajah, A. Abdullah, M. W. Bo and A. Bouazza
Influence of salts on strength of cement-treated clays
C. Modmoltin and P. Voottipruex
Small-scale micropiles to control heave on expansive clays
O. K. Nusier, A. S. Alawneh and B. M. Abdullatit
Validity of Menard relation in dynamic compaction operations
A. Ghassemi, A. Pak and H. Shahir
Discussion
Design of Jet-grouting cut-offs
P. Croce and G. Modoni

Volume 162 ● Issue GI1 February 2009

2 Structures & Buildings

! **Papers**

Strategies for the management of bridges for vehicular impacts
A. Ghose
Ship impact protection for Hungerford Bridge, London, UK
J. Parker
Ship impact on concrete offshore platform legs
J. Jones and R. Fraser
Keg impact damage to fibre-reinforced paving flags
D. Sinnott and R.P. West
Perforation owing to impacts on reinforced concrete slabs
C. Izatt, I.M. May, J. Lyle, Y. Chen and W. Algaard
Reinforced concrete members under drop-weight impacts
Y. Chen and I.M. May
Improving the impact resistance of masonry parapet walls
B. Hobbs, M.W. Gilbert, T. Molyneaux, P. Newton, G. Beattie and S. Burnett.
Impact resistance of fibre-reinforced concrete
S. Mindess and L. Zhang
Investigation on penetration resistance of foamed concrete
A. M. Ahmed Zaidi and Q. M. Li

Volume 162 ● Issue SB1 February 2009

not machine trial version

3 Water Management

! **Briefing**

River modelling and flood mitigation: Malaysian perpectives
Modelling effects of mangroves on tsunamis
F.Y. Teo, R. A. Falconer and B. Lin
Two-dimensional flood modelling of the Damansara River
S.P. Lim and H. S. Cheok
Modelling urban river catchment: a case study in Malaysia
C.S. Leow, R. Abdullah, N. A. Zakaria, A. Ab. Ghani and C.K. Chang
Water quality monitoring of Maong River, Malaysia
S. Said, D. Y. S. Mah, P. Sumok and S. H. Lai

! **Paper**
Computation of afflux ratings and water surface profiles
P. A. Mantz and J. R. Benn
Volume 162 ● Issue WM1 February 2009

4 Waste & Resource Management

! **Papers**
Accounting for food waste: comparative analysis within the UK
P. Bradley, C. Thomas, A. Druckman and T. Jackson
Improving social technologies for recycling
C. Alexander, C. Smaje, R. Timlett and I. Williams
Transport implications of bring-site recycling
A.J. Hickford, T.J. Cherrett and S. Maynard
Gauging HWRC performance from vehicle weigh-ticket data
S. Maynard, T. Cherrett and B. Waterson
Waste segregation presents thermal treatment opportunities
C. Ryu, Y.B. Yang, P. Gilbert, W. Chung, A.N. Phan, A.K. Le, A. Khor, Q. Chen, V.N. Sharifi and J. Swithenbank
Volume 162 ● Issue WR1 February 2009

5 Transport

! **Papers**
Alternative decision-aid tool for pavement management
A. J. L. Ferreira, S. C. N. Meneses and F. A. A. Vicente
Frictional properties of asphalt concrete mixes
A. Ongel, Q. Lu and J. Harvey
Rationality of a non-lane-based car-following theory
B. Gunay
Paying for parking: improving stated-preference surveys
L. Dell'Olio, A. Ibeas and J.L. Moura
A laboratory study on cold-mix, cold-lay emulsion mixtures
I. N. A. Thanaya, S. E. Zoorob and J. P. Forth
Volume 162 ● Issue TR1 February 2009

6 Management, Procurement and Law

! **Briefing**
Supply-chain management in the construction industry
M. Peat and A. McCrea

! **Papers**
Dispute boards on major infrastructure projects
P.H.J. Chapman
Improvement and innovation through collaborative partnerships
S. Wamuziri and S. Madan
Contractor perspective of the new Irish public works contracts
A. Hamilton
Volume 162 ● Issue MP1 February 2009

7 Energy

! **Papers**
Utilisation of geothermal resources
J. W. Lund

Machine-readable version

Methane from biomass: process-integration aspects
S. Heyne and S. Harvey
UK microgeneration. Part I: policy and behavioural aspects
N. Bergman, A. Hawkes, D. J. L. Brett, P. Baker, J. Barton, R. Blanchard, N.P. Brandon, D. Infield, C. Jardine, N. Kelly, M. Leach, M. Matian, A. D. Peacock, I. Staffell, S. Sudtharalingam and B. Woodman.
Transforming low-voltage network into small-scale energy zones
P. Trichakis, P.C. Taylor, P. Lyons and R. Hair.
Volume 162 ● Issue EN1 February 2009

8 Engineering History and Heritage

! **Briefing**
Candian Society for Civil Engineering National History Committee
A. D. Mackenzie

! **Papers**
The establishment of plastic design in the UK
J. Heyman
Early dams
H. Fahlbusch
Introduction of steel columns in US buildings, 1862 - 1920
S. E. Wermiel
Case studies in engineering training and professional education
R. A. Buchanan, D. K. Brown, P. R. Stokes, P. R. Morris and K. Beales.
The effect of bridge failures on UK technical policy and practice
R. J. Bridle and F. A. Sims
Telford in Ireland: work, opinions and influence
R. C. Cox
Volume 162 ● Issue EH1 February 2009

9 Urban Designing and Planning

! **Briefing**
Proactive risk management of urban water supply systems
M. d. C. Cunha

! **Papers**
International urban design: theory and practice
J. Lang
Car-free development through UK community travel plans
D. Morris, M. Enoch, D. Pitfield and S. Ison
Making a case for investment in the public realm
P. Buchanan and N. Gay
Urban design and planning: challenges and opportunities
Urbanwords
R. Cowan
Volume 162 ● Issue DP1 March 2009

10 Maritime Engineering

! **Briefing**
UK government's draft marine bill
J. Brooke
New online marine aggregates research database
J. Moore

PdfMachine trial version

! **Papers**

Comparing environmental effects of Rance and Severn barrages
R. Kirby and C. Retiere
Effect of rudder angle on propeller wash velocities at a seabed
G.A Hamill, D.Ryan and H.T.Johnston
Volume 162 ● Issue MA1 March 2009

11 Structures and Buildings

! **Papers**

Iroko studs connecting limecrete slabs to glulam beams
W. Sebastian, S. Tideswell and R. Mills
Modelling composite repairs to cracked metal structures
M. Roy, C. Lang and I. M. May
Non-linear analysis of strengthened RC beams with web openings
H. Madkour
A new approach to aerostatic analysis of long-span bridges
H. Ma, C. Su and Z. Huang
Volume 162 ● Issue SB2 April 2009

12 Geotechnical Engineering

! **Papers**

Construction of linkspan foundation at Heysham Port, UK
R. S. Gascoigne
Face stabilisation of shallow tunnels using fiberglass dowels
P. P. Oreste
Key parameters dictating strength of lime/cement-treated soils
N. C. Consoli, L. da Silva Lopes Jr, D. Foppa and K. S. Heineck
Estimating clay undrained shear strength using CPTu results
B. Kim, S. Kim, and J. Lee
Discussion
Bridge distress caused by approach embankment settlement
C. A. Jones, D. I. Stewart and C. J. Danilewicz
Volume 162 ● Issue GE 2 April 2009

13 Ground Improvement

! **Papers**

Dynamic compaction of saturated sands and silty sands: theory
S. Thevanayagam, R. Nashed and G. R. Martin
Dynamic compaction of saturated sands and silty sands: results
R. Nashed, S. Thevanayagam and G. R. Martin
Dynamic compaction of saturated sands and silty sands: design
R. Nashed, S. Thevanayagam and G. R. Martin
Fracture grouting of sands by microfine cement grouts
F. Tuncdemir and U. Ergun
Consolidation charts for non-linearly time-increasing loads
R. Jimenez, A. Serrano and C. Olalla
Volume 162 ● Issue GI2 May 2009

14 Engineering History and Heritage

! **Briefing**

Conversation Accreditation Register for Engineers
I. Hume

PdfMachine trial version

! **Papers**

Wellington Street Swing Bridge, Hull, UK
A. Taylor, C. Plants and J. Dickerson
History of high-alumina cement. Part 1: Problems and the Stone report
A. Neville
History of high-alumina cement. Part 2: Background to issues
A. Neville
Canal reservoirs in Great Britain
D. Henthorn Brown
1870s innovation in London Canada's Blackfriars Bridge
F. M. Bartlett, J. M. Graham and J. Camiletti

Volume 162 ● Issue EH2 May 2009

15 Construction Materials

! **Papers**

Selecting sustainable materials for ceilings in Sri Lanka
U. G. Yasantha Abeysundara and S. Babel
Fly-ash-blended lean concrete mixes for concrete blocks
B. V. Venkatarama Reddy and A. Chander
Thermo-acoustic properties of cement-waste-glass mortars
A. Petrella, M. Petrella, G. Boghetich, D. Petruzzelli, U. Ayr, P. Stefanizzi, D. Calabrese, L. Pace and M. Guastamacchia
Durability of rock-filled-dam face-slab concrete
S.-K. Woo, Y.-C. Song and J.-P. Won
Fuzzy logic approach for estimating durability of concrete
M. L. Nehdi and M. T. Bassuoni

Volume 162 ● Issue CM2 May 2009

16 Transport

! **Papers**

Performance of junctions with a high motorcycle proportion
I. Spyropoulou and D. Sermpis
Why should cities changes from DOT to TOD?
C.-N. Li and T.-Y Lai
Estimation of skid resistance and macrotexture thresholds
H. de Solminihac, T. Echaveguren, S. Vargas-Tejeda and A. Chamorro
Modelling surface access mode choice of air passengers
S. Jehanfo and D. Dissanayake
Modelling car ownership in Turkey using neural networks
M. Yasin Codur and A. Tortum
Verification of rutting calculation for unbound road materials
L. Korkiala-Tanttu
Investigating the fatigue performance of grouted macadams
J. R. M. Oilveira, C. Sangiorgi, G. Fattorini and S. E. Zoorob

Volume 162 ● Issue TR2 May 2009

17 Special Issue

! **Papers**

FORENSIC INVETIGATION OF BLAST DAMAGE TO BRITISH BUILDINGS
B. Keane and P. Esper
FORENSIC ENGINEERING OF FIRE-DAMAGED STRUCTURES
J. Ingham

pdfmachine trial version

LEARNING LESSONS FROM FORENSIC INVETIGATIONS OF CORROSION FAILURES
G. John, T. Edwards, A. Wright, M. Broadhurst and C. Newton
FORENSIC STUDY OF WAVE LOADS ON A PIER IN BELGIUM
J. Alderson, W. Alsop, G. Cuomo, Y. Duchene and V. De Vill De Goyet
FORENSIC INVESTIGATION OF FLUVIAL FLOOD DAMAGE IN THE CZECH REPUBLIC
M. Holicky and M. Sykora
A SYSTEMATIC APPROACH TO FORENSIC FOUNDATION ENGINEERING
H. Poulos
FORENSIC LANDSLIDE INVESTIGATION IN HONG KONG
K. Ho, T. Lau and J. Lau
FROENSIC STRUCTURAL ENGINEERING PRACTICE IN THE USA
B. Ratay
LEARNING FROM THE PAST TO IMPROVE FUTURE PRACTICE
S. Matthews and G. Saunders
Volume 162 ● Special Issue One May 2009

18 Urban Design and Planning

! **Briefing**
UK-India research network
N. Dempsey and S. Raman
Learning from Europe
N. Falk
Researching a more resilient built environment
L. Bosher

! **Papers**
Resilience to flooding: lessons from international comparison
J.E. Lamond and D. G. Proverbs
Levels of governance in post-disaster urban planning
J. Hewitt, R. Potangaroa and S. Wilkinson
Performance improvements and delay in development control
P. Allmendinger
Urbanwords
R. Cowan
Volume 162 ● Issue DP2 June 2009

19 Engineering and Computational Mechanics

! **Papers**
Simulation of wave fronts on dry beds using Lagrangian blocks
L. W. Tan and V. H. Chu
Dynamic continuum model for bi-directional pedestrian flows
L. Huang, Y. Xia, S. C. Wong, C.-W shu M. Zhang and W. H. K. Lam
Thermoelastic restrained buckling of composite beams
T. K. Luu and M. A. Bradford
Stability of multi-degree-of-freedom Duffing oscillators
P. Ribeiro
Volume 162 ● Issue EM2 June 2009

20 Water Management

! **Papers**
Stage-discharge relationship for a triangular labyrinth spillway
M. Ghodsian

pdfMachine trial version

Water use prediction by radial and feed-forward neural nets
M. A. Yurdusev, M. Firat, M. Mermer and M. E. Turan
Numerical modelling of braided streams in unsteady flow
H. Takebayashi and T. Okabe
Embedded modified Euler method: an efficient and accurate model
M. H. Afshar and M. Rohani
Influence of clogging on the effective life of permeable pavements
D. Pezzaniti, S. Beecham and J. Kandasamy
Field survey of desiccation fissuring of flood embankments
M. Dyer, S. Utili and M. Zielinski
Optimal design of curved bed trapezoidal canal sections
B. R. Chahar and S. Basu
Volume 162 ● Issue WM3 June 2009

21 Geotechnical Engineering

! **Papers**
Remote sensing for highway management of landslides
M. I. Smedley, R. Paulson and A. Tucker
Finite-element modelling of laterally loaded piles in clay
M. M. Ahmadi and S. Ahmari
Statistical study of no-erosion filter [NEF] test results
P. Tabatabaie Shourijeh and A. Soroush
An apparatus for the plastic limit and workability of soils
G. E. Barnes
Discussion
A Practical design approach for piles with negative friction
H. G. Poulos
Volume 162 ● Issue GE3 June 2009

22 Structures and Buildings

! **Papers**
Novel loading tests on full-scale tapered member portal frames
G. I. B. Rankin, J. C. Leinster and D. J. Robinson
Britain's tall building boom: now bust?
I. R. Skelton, P. Demian and D. Bouchlaghem
Seismic performance of waffled-slab floor buildings
J. Vielma, A. H. Barbat and S. Oller
New methods for road tunnel fire safety evaluation and upgrading
G. A. Khoury, D. Walley and D. McWilliams
Axially loaded RC columns strengthened by steel cages
J. M. Adam, S. Ivorra, F. J. Pallares, E. Gimenez and P. A. Calderon
Discussion
Treatment of risk and reliability in the Eurocodes
T. Vrouwenvelder
Volume 162 ● Issue SB3 June 2009

23 Geotechnical Engineering

! **Papers**
A review of modern particle sizing methods
C. O. R. Abbireddy and C. R. I. Clayton
Limit-equilibrium assessment of drystone retaining structures
C. Mundell, P. McCombie, C. Bailey, A. Heath and P. Walker

pdfMachine trial version

Deformation and stability regression models for soil nail walls
G. L. Sivakumar Babu and V. P. Singh
Predicting uplift resistance of deep piles with enlarged bases
H.-F. Xu, Z. Q. Yue and Q.-H. Qianon
Volume 162 ● Issue GE4 August 2009

24 Construction Materials

! **Papers**
Dimension-stone cladding design with dowel anchorage
R. S. Camposinhos and R. P. A. Camposinhos
Compressive strength of extruded unfired clay masonry units
A. Heath, P. Walker, C. Fourie and M. Lawrence
Relationships between the density and strength of rammed earth
S. Burroughs
Shear behaviour of crushed concrete and bricks
I. Childiroglou, F. O'Flaherty, and A. K. Goodwin
Properties of concrete using high-lime pfa from a UK source
R. Shirley, P. Claisse and E. Ganjian
Racking shear resistance of prefabricated straw-bale panels
M. Lawrence, L. Drinkwater, A. Heath and P. Walker
Volume 162 ● Issue CM3 August 2009

25 Ground Improvement

! **Papers**
Effects of polymers on swelling potential of expensive soils
M. Mirzababaei, S. Yasrobi and A. Al-Rawas
Densification of granular soil by dynamic compaction
M. W. Bo, Y. M. Na, A. Arulrajah and M. F. Chang
Centrifuge model tests on soil-nailed slopes subjected to seepage
V. Deepa and B. V. S. Viswanadham
Stabilisation of desert sands using cement and cement dust
M. Y. Al-Aghbari, Y. E.-A. Mohamedzein and R. Taha
Discussion
Influence of tamper weight shape on dynamic compaction
H. Arslan, G. Baykal and O. Ertas
Volume 162 ● Issue GI3 August 2009

26 Transport

! **Papers**
The role of thermal ratcheting in pavement failures
J. G. A. Croll
Driving style extremes and potential vehicle emission effects
T. Felstead, M. McDonald and M. Fowkes
Control of structural risks arising from track replacement
R. P. Bailey
Pavement-management system for Oliveira do Hospital, Portugal
A. J. L. Ferreira, S. C. N. Meneses and F. A. A. Vicente

Discussion
Cambridge's experience of road user charging: lessons learned
S. Ison, G. Hughes and R. Tuckwell
Volume 162 ● Issue TR3 August 2009

ICE Machine-final version

27 Water Management

! **Papers**

Cost minimisation for multiple-source water supply systems
M. A. R. Shah and M. S. A. Khan
Mathematical modelling of lamella plate settle hydraulics
D. Burgos-Flores, A. Martin-Dominguez, I. R. Martin-Dominguez, M. Perez-Tello and M. T. Alarcon-Herrera
Public-private partnerships in the water and sanitation sector
M. Sohail and S. Cavill
Turbulent length-time scales distributions in hydraulic jumps
S. Kucukali and H. Chanson
Scour depth prediction at bridge piers by Anfis approach
M. Firat
Semi-parametric model of an overtopped dike breach
C. Chinnarasri and A. Saelim

Volume 162 ● Issue WM4 August 2009

28 Structures and Buildings

! **Papers**

Estimation of ultimate stress in external FRP tendons
J. S. DU and F. T. K. Au
Stress limits for aramid fibres
I. P. Giannopoulos and C. J. Burgoyne
Experimental assessment of bonded FRP-to-steel interfaces
K. A. Harries and P. Webb
Adhesive bonding in steel beams strengthened with CFRP
J. Deng and M. M. K. Lee
Strengthening wrought-iron structures using CFRP
S. S. J. Moy and H. W. J. Clarke
Uptake swelling and thermal expansion of CFRP tendons
P. Scott and J. M. Lees
Environmental effects on the failure of GRP multi-bolt joints
G. J. Turvey and P. Wang

Volume 162 ● Issue SB4 August 2009

29 Waste and Resource Management

! **Briefing**

Overview of the work of the Sue waste consortium
W. Powrie, K. Riley and A. M. Salter

! **Papers**

Estimating household material flows in deprived areas
C. Alexander, A. Druckman, T. Jackson and C. Osinski
Evaluation of bulky waste and reuse schemes in England
C. Alexander, A. Curran, C. Smaje and I. Williams
Thermal technology scale in future waste management strategies
A. Castillo-Castillo, M. Leach, L. Yassin, P. Lettieri, S. J. R. Simons, C. Ryu, J. Swithenbank and V. Sharifi
From incineration to advanced fluid-bed gasification of waste
L. Yassin, P. Lettieri, S. J. R. Simons, A. Castillo-Castillo, M. Leach, C. Ryu, J. Swithenbank and V. Sharifi

Volume 162 ● Issue WR3 August 2009

PdfMachine trial version

30 Special Issue

! **Papers**
KEEPING WATER IN THE WADIS OF ARABIA'S PERFUME CAPITAL
R. Chakraborty
SATELLITE MAPPING IN CITIES: HOW GOOD CAN IT GET?
C. Hancock, G. Roberts and A. Taha
ADVANCE IN RESEARCH ON FIRE ENGINEERING OF STEEL STRUCTURES
Y. Wang
WIRELESS SENSOR NETWORK: CREATING 'SMART IINFRASTRUCTURE'
N. Hoult, P. Bennett, I. Stoianov, P. Fidler, C. Maksimovic, C. Middleton, N. Graham and K. Soga
Volume 162 ● Issue CE3 August 2009

31 Urban Design and Planning

! **Briefing**
Spaces and places
L. Walker and M. Simmons
Croydon, UK regenerates from within
J. Kerr
Capacitycheck urban design skills appraisal
J. Smachylo

! **Papers**
Global flagships, local impacts
B. Doucet
Resilience and the city: the water sector
W. A. H. Hamilton
Post-occupancy evaluation and sustainability: a review
F. Stevenson
Data integration for quantitative analysis of sustainability
D. Fu and G. Aouad
Volume 162 ● Issue DP3 September 2009

32 Maritime Engineering

! **Papers**
A stochastic method for predicting average beach shape
Y. Li and D. Reeve
A numerical model of coastal overwash
C. Donnelly, M. Larson and H. Hanson
Analytical model of beach erosion and overwash during storms
M. Larson, C. Donnelly, J. A. Jimenez and H. Hanson
Regional vulnerability analysis of Catalan beaches to storms
E. J. Mendoza and J. A. Jimenez
Modelling shoreline evolution to enhance flood risk assessment
S. Stripling and M. Panzeri
Volume 162 ● Issue MA3 September 2009

Pdfmachine trial version

MANAGING WATER SCARCITY AND QUALITY DETERIORATION IN PAKISTAN: CHALLENGES AND OPTIONS

By

Dr. Allah Bakhsh Sufi[1] Talib Hussan[2] and Khalid Javed[3]

ABSTRACT

Integrated water resources management is based on the concept of water being an integral part of an eco-system, a natural resource and a social economic good, whose quantity and quality determine the nature of its use (Agenda 21, United Nations, 1992). A water resource that is reliable, in terms both of its quantity and its quality, is a pre-requisite for the survival of human civilization and socio-economic development. Water scarcity, gradual deterioration, aggravated pollution and infra-structure development has increasingly created conflicts over the uses of this resource. If we consider the maintenance of adequate access to and supply of good quality water, we need to look at how this is to be achieved beyond the provision of safe drinking water and sanitation. Maintaining a safe water supply means that overall river basin management, agriculture practices and other works are important. Ultimate need is to make certain that river basins and ground waters are managed in their entirely. Steps need to be taken to make provision for environmental flows for healthy river systems as healthy functioning of river systems and groundwater are essential for people, plants and animals.

1. INTRODUCTION

Water is precious and eternal source of life on earth. It has direct bearing on almost all sectors of the economy. The increasing population pressure & industrialization has placed a great demand of water with an ever increasing number and intensity of local and regional conflicts over its availability and use. Availability of water in Pakistan has alarmingly declined from 5000 cubic meters per capita in 1950 to nearly 1,000 cubic meters in 2010, because of increase in population, inefficient irrigation, mismanagement and unequal water rights. Increasing deterioration and pollution, depleting biodiversity, desertification, over exploitation of natural resources, receding glacial phenomena, water scarcity and degrading economic system are posing a huge challenge to sustainable farming and economic development.

Nearly 75 percent of population or some 125 million people have no access to clean drinking water. The situation is worse in rural areas. Water crisis has several serious health, social and political implications. Water borne diseases such as cholera, gastro, diarrhea, hepatitis and typhoid cost the national exchequer 2 percent of GDP (Rs. 125 billion) annually because of poor access to safe drinking water and better sanitation. The situation is becoming precarious with the passage of time. Over 60% of the population gets their drinking water from hand or motor pumps, with the figure in rural areas being over 70 percent. Areas, where underground water is brackish, use of surface water for

Machine translation

---

1. Chief Engineer (WRPO) WAPDA, Lahore.
2. Director (Agriculture) WRPO, WAPDA, Lahore.
3. Research Officer (Agri), WRPO, WAPDA, Lahore.

domestic purposes is a serious issue. Links between water quality & health risks are well established. According to UNCEF, 20-40 percent of hospital beds in Pakistan are occupied by patients suffering from water borne diseases.

In 1960s and 70s it was proclaimed that the "Green Revolution" would solve all the food problems. However, the new mode of cultivation, due to use of chemical fertilizers, herbicides, pesticides have destroyed bio-diversity, killed fish in the rivers, created salty soils and polluted rivers and source of drinking water. Over exploitation of groundwater and climate change phenomenon is another upcoming bound to complicate the situation further. Good quality water offers assurance against famine for food security and sustainability. Pakistan is a country with large arid & semi-arid regions where rainfall is sparse and insufficient for crop water requirements. Globally 40% of food production is produced from irrigated land. That is just 17% of cultivated land. But in Pakistan where annual rainfall is about 240 mm, 95% of food production comes from irrigated areas. Pakistan's canal irrigation system operates largely in a water-short environment. Although agricultural scientists have been doing remarkable job to cope with this situation, it is time to review the current situation, co-ordinate the individual efforts and develop a national workable strategy for sustainable water resource development & management.

TABLE-1
WHERE DOES PAKISTAN STAND IN
WATER AVAILABILITY vis-à-vis POPULATION

Year	Population (Millions)	Growth Rate	Total Water Availability		Per capita water availability ($m^{3)}$
			Billion cubic meter	MAF	
1951	34	0	178.8	144.9	5260
1961	43	2.38	178.8	144.9	4159
1971	63	3.89	178.8	144.9	2838
1981	84	2.72	178.8	144.9	2129
1991	111	2.83	178.8	144.9	1611
2001	143	2.60	178.7	144.9	1250
2010	172	2.10	178.6	144.7	1038
2020	204	1.70	178.9	145	877
2025	221	1.60	178.9	145	809
2030	238	1.50	178.7	144.8	751
2040	273	1.40	178.7	144.8	654
2050	311	1.30	178.8	144.9	575

Population Censuses Record					
Year	1951	1961	1972	1981	1998
Population	34	43	65	84	131

pdfmachine trial version

In future there are two kinds of challenges: One is the quantity of agricultural production and other is quality as well. The quality of agricultural product is a major concern for the WTO challenge. Thus it is very much required to develop crop production technology for sustainable production & increase the cropping intensity by bringing additional land under cultivation. Breeders should breed high yielding varieties. Similarly agricultural engineers will have to concentrate their efforts to modify and improve the existing irrigation techniques that are economical and well suited to our farming community and environment, especially to increase the overall water efficiency and salt balance issues upcoming through surface and groundwater application.

1.1 Present Situation

- Pakistan's current population of 168 million is expected to grow to about 221 million by the year 2025. This has a direct impact on the water sector for meeting the domestic water requirements of the people and for meeting the needs of agriculture to support increasing food requirements and produce an exportable surplus for earning foreign exchange. Over time per capita water availability and land use in Pakistan is shown in Fig. I and Fig. II respectively.

- Pakistan is now essentially at the limit of its water resources. There is some potential for additional storage but this is limited and, at present, the lack of consensus on storage between the provinces hampers its development. Additional water must be derived through conservation, especially in irrigation, where over 95% of water is used.

- While there has been continuous improvement in agricultural yields they remain significantly lower than their potential. Hence water for irrigation is not being utilized as effectively as it could with regard to crop production.

- Water quality in the rivers and other surface waters is low and deteriorating because of unchecked disposal of untreated municipal and industrial wastewater. Water quality monitoring and information management is lacking and yet is crucial to any water quality improvement programme.

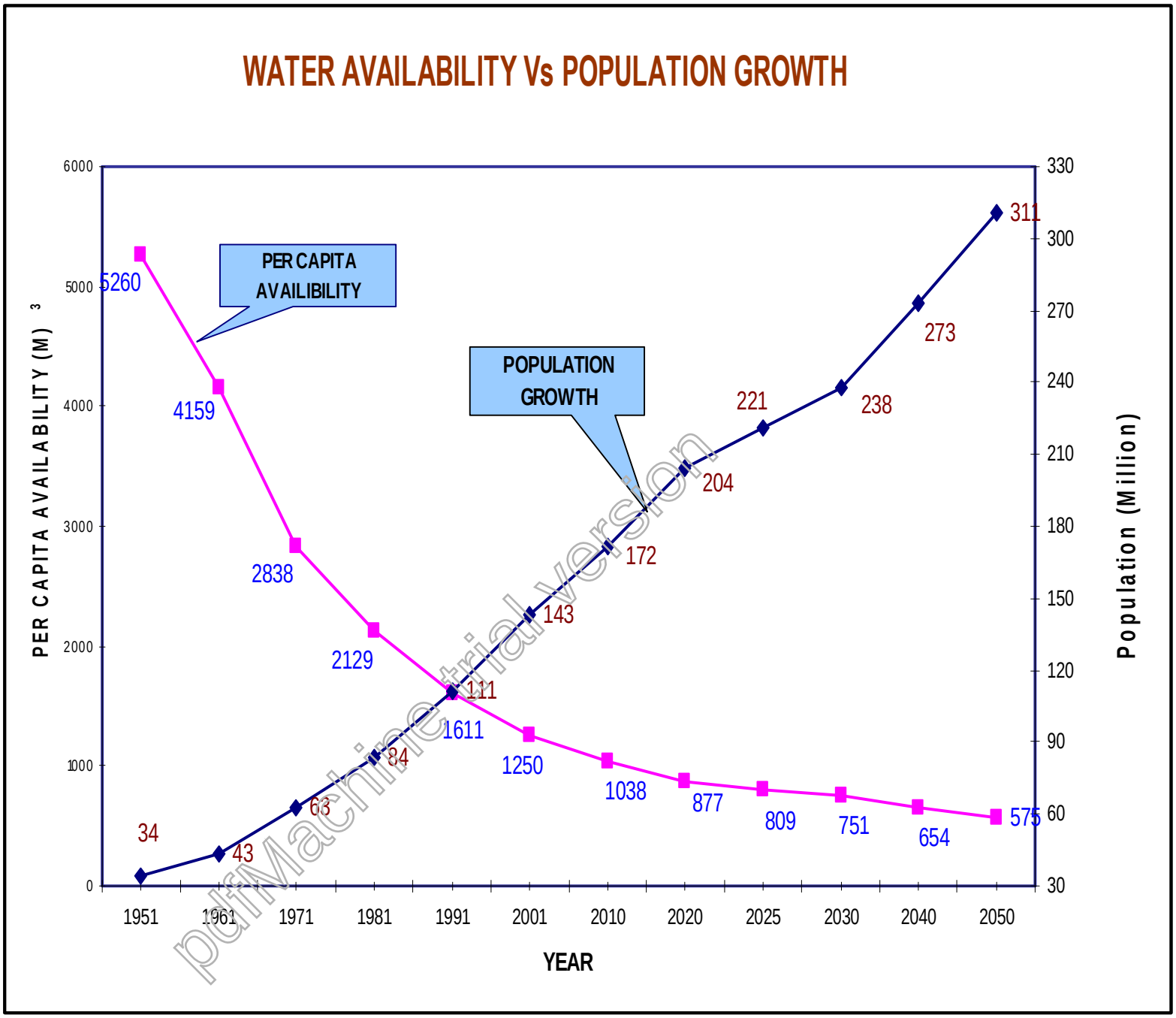
- Information on water resources and, especially, water use is limited and not very accessible.

- Public awareness and understanding of water issues is lacking and needs to be addressed in order to garner public support for the changes in water management that will be needed in the immediate and longer term future.

- Access to clean domestic water in the urban and rural sub-sectors is low and significant investment will be required to improve service and keep up with the population growth.

- At a time when Pakistan is in dire need of investment in the water sector, there have been considerable delays in project implementation. There have

pdfMachine trial version

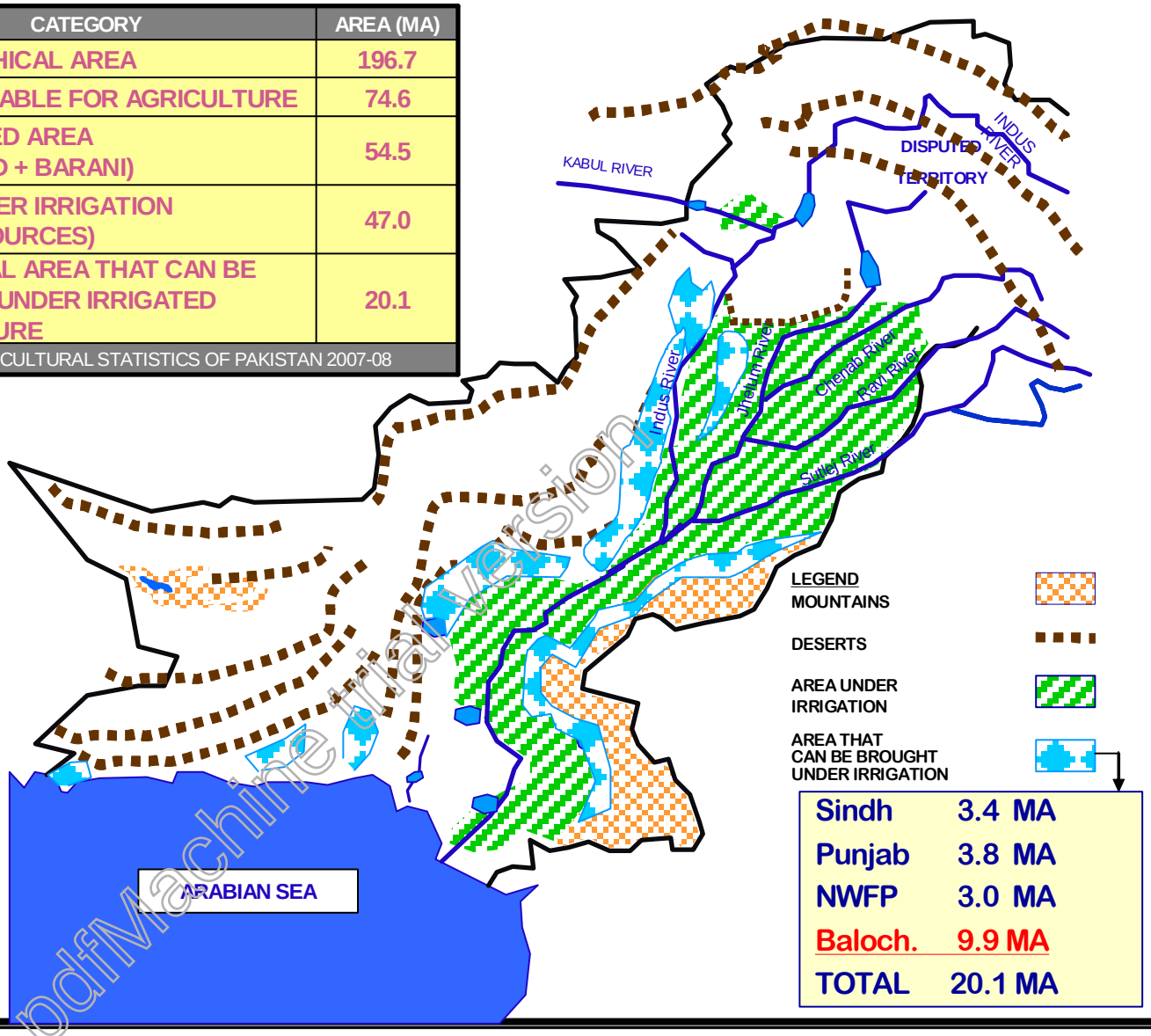


pdfMachine trial version

LAND USE IN PAKISTAN

CATEGORY	AREA (MA)
GEOGRAPHICAL AREA	196.7
AREA SUITABLE FOR AGRICULTURE	74.6
CULTIVATED AREA (IRRIGATED + BARANI)	54.5
AREA UNDER IRRIGATION (BY ALL SOURCES)	47.0
ADDITIONAL AREA THAT CAN BE BROUGHT UNDER IRRIGATED AGRICULTURE	20.1

SOURCE: AGRICULTURAL STATISTICS OF PAKISTAN 2007-08



pdfMachine trial version

0

been several causes for this, but most result in some way with lack of ownership on the part of the implementing agency.

2. Uses of Water

2.1 Water Availability

The average annual inflow of the Western Rivers during post Tarbela period 1975-2001) at the rim stations (Indus at Kalabagh, Jhelum at Mangla and Chenabat Marala) is 143.18 MAF (176.63 BCM). 82% of the total inflow is in the Kharif season (April – September) and 18% of the total-flows during the Rabi season (October – March).

The three eastern rivers, Ravi, Sutlej and Beas, have been allocated to India for its exclusive use, but un-utilized flows enter Pakistan. Allowing for the reduction in the contribution from the eastern rivers and the allowable uses by India on the western rivers the total long term surface water available in the Indus Basin is effectively equal to the inflow of the western rivers i.e. 143.18 MAF (176.63 BCM).

2.2 Irrigation

Irrigated agriculture is the major user of both the surface and groundwater resources of Pakistan. The average annual river diversions for irrigation in the Indus Basin are of the order of 103.84 MAF (128.10 BCM) for irrigating over 36 million acres (14.6 million hectares). Out of this 66.83 MAF (82.44 BCM) on average are diverted during the Kharif period, while 37.01 MAF (45.01 BCM) are diverted during the Rabi period.

During the Kharif seasons, on average basis of supplies Punjab used 34.3 MAF (42.3 BCM) annually on average, while Sindh & Balochistan used 31.4 MAF (38.7 BCM) and NWFP used 2.35 MAF (2.9 BCM). During the Rabi periods of the same period, average withdrawals by Punjab, Sindh & Balochistan and NWFP were 19.87 MAF (24.5 BCM), 16.06 MAF (19.8 BCM) and 1.46 MAF (1.8 BCM) respectively.

An estimated 41.6 MAF (51.3 BCM) are pumped annually from the groundwater reservoirs. Most of the groundwater abstraction is in the Punjab, estimated at 34.0 MAF (41.94 BCM) in 1999-2000, followed by Sindh at 5.0 MAF (6.17 BCM), Balochistan at 0.5 MAF (0.62 BCM) and NWFP AT 2.1 MAF (2.59 BCM). More than 90% of groundwater abstracted is used for irrigation.

The recent drought has caused considerable reduction in irrigation supplies. As a result there was a negative growth in agriculture. This has impacted on the growth of GDP.

It is interesting to note that there have been yield increase in some crops, notably wheat, despite, or in fact, because of the drought. The increases are in the areas of Punjab and Sindh which are normally waterlogged and have saline groundwater problems. The increases are attributed to a reduction in Waterlogging due to lower levels of water use as canal diversions have decreased. It remains to be seen whether the lesson here will be taken on board once the drought ends and water allocations are back to normal.

pdfMachine trial version

It is not possible to meet all future agricultural requirements with existing water resources alone, even with the development of additional storage. Much of the future requirements will have to be met through increased crop yields, increased water use efficiency, use of saline water for agriculture and recycling of effluents etc.

Table-2 WATER DEMAND

Population	**2010** **2025**	**168 million** **221 million**
Urban Population	Currently 2025	35% 60%
Total Area	196 M Acres	
Cultivable	73 MA	
Cultivated	52.5 MA	
Remaining	21.5 MA Needs Add. Water	
To increase the crop yield requires additional water		
Net Water Requirement	2010-11 2024-25	89 MAF 114 MAF
Domestic Demand	Currently 2025	4.0 MAF 10.5 MAF

2.3 Domestic and Industrial Water

The present water use for municipal supplies in the urban sector is of the order of 4.3 MAF (5.3 BCM). Most urban water is supplied from groundwater except for the cities of Karachi and Hyderabad and part of the supply to Islamabad. The increased population will exert additional pressure on the already strained water supply and sanitation facilities. The demand for municipal and industrial supplies in urban areas is expected to increase to about 7.1 MAF (8.7 BCM) by 2011 and 12.1 MAF (14.0 BCM) by 2025.

The total water requirement for non-irrigation use is estimated at 8.96 MAF (11.0 BCM) in 2011 and 15.3 MAF (18.9 BCM) in 2025. Irrigation water use will face increased competition from the municipal and industrial water supply sector.

2.4 Competition Between Uses

Irrigation dominates water use in Pakistan and is expected to continue as the major user of both surface and groundwater into the future. The existing reservoirs are operated with priority for the irrigation uses of the provinces as stipulated in the Water Accord. Hydropower generation is a secondary benefit from the reservoirs. Compared to irrigation the current demand for urban and rural water supply is minimal. However, as development proceeds and the population as well as country's economy grows, competition for water resources will become a major concern.

With the expected increase in the demand for supply of water for urban and rural domestic and industrial use, plus the needs of the environment, coupled with the limited overall water resources, it is likely that some water will need to be diverted from irrigation to these other uses. Currently, the irrigation system runs with overall efficiency of about 40%. There is some scope for conservation of water through increasing irrigation efficiencies to ensure water for all users, as well as ensuring adequate supply for irrigation itself. Urgent action is required for reducing losses from the irrigation system.

pdfMachine trial version

Disposal of effluents from agricultural drainage, municipal waste and industrial effluents into the canals, rivers and other water bodies are a major issue due to their effect on other water users. The disposal of untreated municipal and industrial effluent from all cities is already having significant negative impacts on downstream water quality.

Table-3
Competing Water Uses: Interaction

	Sanitary Control	*Hydro-power*	*Irrigated agri-culture*	*Domestic water supply*	*Industrial water supply*	*Waste water disposal*	*Naviga-tion*	*Aqua-culture*	*Recreation / Fisheries*
Salinity Control	***2***	***C***	***C***	***1***	***1***	***2***	***0***	***2***	***2***
Hydro-power			***1***	***0***	***0***	***0***	***0***	***2***	***2***
Irrigated agriculture				***3***	***3***	***3***	***0***	***C***	***1***
Domestic water supply					***1***	***C***	***0***	***0***	***0***
Industrial water supply						***C***	***0***	***2***	***2***
Waste water disposal							***0***	***2***	***2***
Navigation								***0***	***0***
Aqua-culture									***C***

O: no competition 1: minor competition 2: moderate competition 3: severe competition C: complementary use

pdfMachine trial version

3. Groundwater Quality

3.1 Irrigation Waters

The Indus Basin is formed by alluvial deposits carried by the Indus and its tributaries and is underlain by an unconfined aquifer covering about 15 million acres (6 million ha) in surface area. In the Punjab about 79% of the area and in Sindh about 28% of the area is underlain by fresh groundwater, which is mostly used as supplemental irrigation water and pumped through the tubewells. Some groundwater is saline and water from the saline tubewells is generally put into drains and, where this is not possible, it is discharged into the canals for use in irrigation after diluting with the fresh canal water.

About 42 MAF (52 BCM) of groundwater is pumped for irrigation use and for urban & rural drinking water supplies. Province-wise the groundwater usage is 34 MAF (42 BCM) in Punjab, 3.5 MAF (0.6 BCM) in Balochistan. Both the groundwater potential and use is

very limited in AJ&K as compared to other provinces. In Northern Areas the potential for groundwater exploitation is virtually none.
Groundwater use is nearing the upper limit in most parts of Pakistan. The groundwater table in most of the fresh water areas is falling, therefore the potential of further groundwater exploitation is very limited. For future projections it is estimated that the additional contribution by groundwater may increase at best by 1-2 MAF (1.2 – 2.4 BCM).

The quality of groundwater ranges from fresh (salinity less) than 1000 mg /L TDS) near the major rivers to highly saline farther away, with salinity more than 3000 mg/L TDS. The general distribution of fresh and saline groundwater in the country is well known and mapped as it influences the options for irrigation & drinking water supplies. In the country some 14.2 million acres (5.75 Mha) are underlain with groundwater having salinity less than 1000 mg/L TDS, 4.54 million acres (1.84 Mha) with salinity from 1000-3000 mg/L TDS and 10.57 million acres (4.28 Mha) with salinity more than 3000 mg/L TDS.

Table-4 Water Quality Standards

Water Class	Electrical conductivity dS/m	Salt concentration mg/1	Type of water
None-saline	<0.7	<500	Drinking and irrigation water
Slightly saline	0.7-2	500-1500	Irrigation water
Moderately saline	2-10	1500-7000	Primary drainage water and groundwater
Highly saline	10-25	7000-15,000	Secondary drainage water and groundwater
Very highly saline	25-451	5,000-35,000	Very saline groundwater
Brine	>45	>45,000	Seawater

pdfMachine trial version

Punjab
About 79% of the area in Punjab province has access to fresh groundwater. Some 9.78 million acres (3.96 Mha) are underlain with groundwater of less than 1000 mg/l TDS, 3 million acres 1.22 Mha) with salinity ranging from 1000 to 3000 mg/l and 3.26 million acres (4.32 Mha) are underlain with groundwater of salinity of more than 3000 mg/l TDS. In the province, saline waters are mostly encountered in Central Doab areas. Cholistan area in the southern Punjab is well known for highly brackish waters, which can not be used for drinking as well as irrigation purposes.

3.1.2 Sindh

Around 28% of the area in Sindh province has access to fresh groundwater suitable for irrigation. Close to the edges of the irrigated lands, fresh groundwater can be found at 20 to 25 m depth. Large areas in province are underlain with groundwater of poor quality.

Indiscriminate pumping has resulted in contamination of the aquifer at many places where salinity of tube well water has increased. The areas with non-potable, highly brackish water include Thar, Nara and Tharparkar.

3.1.3. N.W.F.P.

In NWFP abstraction in access of recharge in certain area such as Kark, Kohat, Bannu and D.I. Khan has lowered the water table and resulted in the contamination from underlying saline water.

3.1.4 Balochistan

The Makran coastal zone and several other basins contain high brackish groundwater. As there is no alternative, local communities use groundwater for drinking purposes with TDS as high as 3000 mg/l.

It is apparent from the above discussion that as is the case with the quality of surface water, the quality of ground water in many areas is deteriorating due to contamination from industrial and municipal wastes and also due to salt water intrusion as a result of over pumping. Water quality of both surface and groundwater is becoming one of the major water resources issues.

For each of the % ages indicate whether stable, increasing or decreasing

Condition	Severe Impact	Moderate Impact	Slight Impact	No Impact
Area of aquifers where watertables are drawn by pumping	6.4% (Increasing)	3.6% (Increasing)	2.4% (Increasing)	87.6% (Decreasing)
Area of aquifers where chemical water quality is adversely affected by human activity	12% increasing	9% increasing	9% increasing	70% decreasing
Area of aquifers where biological water quality is adversely affected by human activity	Negligible	Negligible	Negligible	99%

pdfMachine trial version

3.1.5 Estuarine & Coastal Zones

The coastal and estuarine zone of Pakistan is mainly affected by human activities in deltaic region except for small fishing villages scattered on the shoreline in Sindh & Balochistan. The kind of impacts generated by human activities include:

Estuarine

- Decrease in fish and other aquatic species.

- Depletion of mangrove system.
- Hyper-salination of creek system & depletion of habitat.
- Pollution through municipal sewerage and industrial effluent
- Sea water intrusion.

Coastal

- Loss of habitat
- Eutrophication
- Bio-accumulation of toxic substances
- Traffic & oil pollution in harbour areas.
- Smothering of inter-tidal flora & fauna
- Marine pollution due to port and harbour

The Indus estuarine area was once well known for its shellfish, Oyster, window pans oysters, shrimps and small pearls from species in the creek system. The catches of these landings have declined or completely ceased due to changes in hydrographic regions and environmental degradation. Traveling has also destroyed species in estuarine areas, which act as breeding and nursery grounds for several fish species. Traveling in the estuarine areas should be either banned or controlled and monitored.

3.1.6 Industrial Impacts

More than 60% of the industries of the country are located in five industrial complexes near the coast in Sindh and Balochistan. Sindh Industrial Trading Estate (SITE), Hub Industrial Trading Estate (HITE), Landi Industrial Trading Estate (LITE), Korangi Industrial Trading Estate (KITE) and the Port Qasim/Steel Mill Complex , Karachi, with an estimated population of 13-14 million generates more than 262 MGD (499.3 MCP) of untreated domestic and industrial waste water. The disposal of periodic Oxygen deficient water in the proximity of coastal region has resulted in many important fish species moving farther away from the fishing zones.

Quantitative estimates of oil pollution on the Karachi creeks are lacking. However, observations indicate considerable amounts of oil and tar balls from shipping traffic washed up on the coast. This is probably due inadequate flushing water. The influence of pollution from Karachi Harbour and Gizri-Korangi creek system is noticeable to a radius of 10-20 Km offshore. Flotsam and oily wastes are visible to a radius of 5 Km. Bottom sediments show sings of organic pollution to a distance of 15 – 20 Km offshore from Korangi – Phitti creek opening

pdfMachine trial version

3.2 Domestic Waters

Poor microbial quality of drinking water supplies is by far the dominant water quality issue for health in Pakistan. In most of the cities the municipal water is unsafe to drink and does not meet WHO guidelines. In cities the quality of the water is generally compromised with the distribution system by inadequacy or lack of chlorination, cross-connections from sewage lines, poor maintenance and illegal connections. Many surface water treatment plants do not observe basic procedures to ensure water quality. It is estimated that 90% of the country's population is exposed to unsafe drinking water.

There is an increasing trend in cities and urban areas on the use of costly bottled drinking water. Several bottling companies have started operating but a recent survey, reported in the Press, showed that the quality of water supplied by a number of these companies also did not meet WHO standards for drinking water.

For water in rural area across Pakistan, there is simply no system in place to assess the quality of drinking water. The availability of drinking water in rural areas where groundwater is saline is a serious problem.

For each of the % ages indicate whether stable, increasing or decreasing

Condition	Severe Impact	Moderate Impact	Slight Impact	No Impact
%age (by length) of coastal line whose aquatic eco systems are affected by human activity	11.5%	15.3%	8.8%	64.4%
%age (by area) of estuaries in which the salt water interface has advanced in land as a result of human activity	90%	10%	0 %	0 %
%age (by area) of estuaries whose aquatic eco systems are adversely affected by human activity	90%	10%	0 %	0 %

Non-Machine-Readable version

3.2.1 Sindh

In Karachi the tap water is not fit for drinking. Almost 95% of shallow groundwater supplies are faecally contaminated and surveys suggest that similar pollution occurs elsewhere in the province of Sindh. The presence of chlorinated pesticides in shallow groundwater sources in Karachi has also been reported. Many rural areas of the province (in particular Mirpur Khas and Thar) are also faced with high fluoride content in the drinking water.

3.2.2 NWFP

The quality of drinking water in NWFP is often low due to the aging distribution system, the lack of treatment facilities and contaminated water sources in some urban areas. Drinking water in Peshawar is generally unfit for human consumption due to faecal contamination. In certain saline areas in Nowshera, Kohat and D.I.Khan, water is unfit for drinking due to a high salt content. Nitrate concentrations as high as 946 mg/l have been reported from rural areas around Gadoon.

3.2.3 Punjab

The drinking water quality in major urban centres of the Punjab seldom meets WHO Guidelines. Samples obtained from Lahore, Rawalpindi and Islamabad is reported to be unfit for human consumption due to faecal contamination. High concentrations of nitrates have also been detected in drinking waters in Islamabad, Rawalpindi, Gujar Khan, Kahuta, Murree and Taxila. Nitrate leaching from heavy fertilizer use is known to be an issue in southern Punjab. Many areas near Lahore have very high fluoride content in drinking water supplies, which resulted in ailments in the consumers.

3.2.4 Balochistan

In Balochistan, the main environmental health problems arise from higher levels of faecal coliform, viruses and pathogens in water supplies obtained even from deep wells. The problem is specially acute in Quetta. Some of shallow aquifers are contaminated by sewerage & other pollutants. An additional problem is that of hyperfluorosis. Drinking water in Jafarabad, Dera Bugti, Mastung & Bolan areas have been found to contain high fluoride content.

4. Areas to be addressed urgently at Public & Private Levels

4.1. Water Storage

To meet future water requirements, it would be necessary to create large storages on Indus River. The Federal Government through WAPDA has launched a comprehensive integrated water resource and hydropower development Mega Plan Vision 2025 for development of water reservoirs and hydropower generations. Under this programme water storage/reservoir sites of about 65 MAF total capacity and power potential sites of 35,000 MW in the whole of Pakistan including Northern Areas & AJ&K have been identified. The Vision Programme envisaged a comprehensive portfolio for undertaking feasibility studies, detailed engineering designs and preparation of tender documents of a number of projects. Under Vision 2025 Programme, implementation of such projects as Raised Mangla Dam, Gomal Zam Dam, Hingol Dam and Mirani Dam etc. has been undertaken on fast track basis. Basha Diamer, Akhori, Munda dams have been taken up already or would be taken up in future.

pdfMachine trial version

4.2. Environment

Through out the country river and stream behaviour is changing due to increased diversions, construction of reservoirs and deforestation of catchments. Silt loads, particularly in the wet season, create a problem in all sub-sectors using surface water. Suspended matter in the water creates a greater rate of component wear on pumps and turbines and increases filtration problems in any situation requiring clean water. Sedimentation of reservoirs is resulting in reduction of capacity and other irrigation infrastructure poses an ongoing maintenance problem in an environment where attention to maintenance is not given a high priority.

Environmental use of water has not received recognition in the past. For future development of storage reservoirs allocations may be made for the environmental use so that the downstream adverse effects are mitigated. Significant further investment is

required in public awareness and education, farmer training and institutional strengthening.

Pakistan is likely to face acute problems in near future, as its water resources will not be adequate to supply water to cities, towns and rural areas, or to produce enough food crops to meet the requirements of an increasing population. The most environmental concern is the low quality of surface water, which should be addressed through improved wastewater treatment in both the urban water and industrial sub-sectors.
Water quality monitoring and information management is badly lacking in Pakistan. Developing a monitoring system, which would include the establishment of water quality laboratories, and training of personnel for those labs, should be given emphasis in a water sector strategy.

Watershed management, especially the loss of forests in the upper catchments which, among other things, contributes to the sedimentation of reservoirs is a concern. However, at present there is little information on the impact of forest loss. Initial research on this would be warranted. There are several environmental issues which, if unchecked, will make the water use unsustainable. These include:

- Widespread contamination of surface waters due to disposal of agricultural drainage and untreated municipal and industrial effluents causing high incidence of water-related disease;
- waterlogging and salinity;
- over exploitation of groundwater in certain areas;
- limited forest cover and deforestation;
- saline intrusion into aquifers due to over pumping and
- reduction in the capacity of major reservoir due to siltation.

4.3 Federal and Provincial Institutions

At the Federal level Ministries of Water & Power, Food, Agriculture & Livestock, Planning & Development, Environment, Local Government and Rural Development and Ministry of Finance & Economic Affairs deal with water, agriculture and energy related issues. The Principal institution involved in the planning, design, implementation of irrigation, drainage and power projects at the federal level is the Water & Power Development Authority (WAPDA).

At the Provincial Level Departments of Irrigation & Power, Planning & Development, Food and Agriculture, Physical Planning & Housing Department (Punjab) and Public Health Engineering Departments (Other Provinces) and Finance Departments deal with water and agriculture related issues. The Provincial Irrigation Departments/Provincial Irrigation & Drainage Authorities (PIDAs) are responsible for the planning, design, implementation & operation of irrigation & drainage systems and the flood control infra-structure in their respective provinces. While there is no general concern with the

pdfMachine trial version

organizational structure of water institutions in Pakistan, there is no body at the federal level which has the responsibility to oversee the water sector as a whole and which has no vested interest in construction or other forms of water sector development.

4.4 Crops Substitution

The types of crops grown need to be rationalized to ensure that the crops grown are efficient in terms of water use and economic productivity. The traditional cropping pattern of rice and wheat has benefited from increased irrigation supplies and these two crops will remain important in Pakistan. However, sugarcane production, for example, has resulted in poor economic allocation of resources and wasteful over production that could not be efficiently marketed, resulting in a break down of support price mechanism and major loss to the producers. Over investment in the sugar industry and increased allocation of land and water to sugarcane has resulted in reducing resource availability to other crops. Modern research has shown several alternative cropping patterns that can raise productivity of existing farm systems. In the intensive agriculture systems of Punjab, Sindh and NWFP, there are ample opportunities to increase farm income from technologies such as zero tillage, introduction of high value crops like sunflower, pulses, vegetables and orchards etc.

4.5 Introduction of Sprinkler and Drip Irrigation

There is potential for reducing water use through introducing sprinkler and drip irrigation for some crops in some areas. Capital investment can be intensive for modern mechanized irrigation. Consideration should be given to introduction and means of financing these modern irrigation system in the scenario of present increasing scarcity of water in Pakistan.

4.6 Recycling of Effluents after Treatment

There is potential to re-use waste water effluent after treatment. However, care must be taken to ensure that the effluent is treated before use for irrigating food crops. Treatment of waste water effluent needs to be given priority from the environmental and water quality concerns.

4.7 Use of Saline Water for Agriculture

The use of saline water for cropping is restricted to growing salt resistant crops. Such crops as grasses for fodder, bushes and trees have proved successful in providing a reasonable economic return from areas affected by saline soils or using saline water for irrigation. This may not have a wide spread benefit, there is likely a potential for local improvements in farmer income.

4.8 Flood Water / Hill Torrents Conservation

One mode of rain harvesting which is used in Pakistan in watersheds of hill torrents and small streams is through construction of check dams to retard the speed of flows and construction of delay action dams to flatten the flood peaks and use the run off either for recharging the groundwater aquifer or to divert it into channels for use in flood irrigation. This technique has become popular in the water scarce areas of Balochistan, NWFP and parts of Punjab. In urban and rural areas rain harvesting can also be introduced in

pdfMachine trial version

public and community wells situated near slums, draining water from nearby roof-tops and streets into them.

4.9 Conservation and Productivity

Country's productivity is one of the lowest in the world. The future strategy should be to look into enhancing productivity of existing irrigated land with high efficiency irrigation and adopt knowledge based technologies. Similarly in other water related sub sectors, conservation technologies can reduce or at least meet their water requirements more efficiently.

4.9.1 Desalination

Water quality for domestic use is a major problem across Pakistan. There are significant costs associated with the treatment of the raw water. For coastal cities such as Karachi, and inland cities, which have access to brackish groundwater, there is potential to benefit from desalinating water which should be investigated as a possible future source.

5. Conclusions

- Pakistan is presently faced with the situation that all its developed water resources are inadequate to meet the irrigation, power and other water requirements and it will not be able to meet its growing water requirements by 2025.

- Future water needs can be met by using available water resources more efficiently but in many cases it will be necessary to make increased use of low quality water for agricultural production.

- The irrational use of low quality groundwater has resulted into mining & secondary salinization.

5.1 Recommendations

- Impacts of low quality water for agriculture must be assessed at the farm level as well at the regional level.

- Traditional surface irrigation methods should be altered/replaced by properly designed and managed micro sprinkler & trickle irrigation systems.

- Disposal of industrial & sewerage effluents should be brought under strict legal frame work.

pdfMachine trial version

REFERENCES:

1. Water Resources strategy study ADB TA 3110 Pak by Hal crow Group Ltd in association with ARCADIS Euro consult, June 2002.

2. Economic Survey 2006-07 & 2007-08 GOP.

3. Ministry of Food, Agriculture & Livestock; Agricultural Statistics of Pakistan 2007-08 GOP.

4. Pakistan Engineering Congress in collaboration with WAPDA, World Water Day March, 2007.

5. Pakistan Statistical Year Book 2007-08.

6. Global Water Partnership (2000-01) “Draft South Asia – Water Vision 2025” Country Report.

7. International Waterlogging & Salinity Research Institute (IWASRI) May, 1999 “Management Aspects of Use of Brackish Drainage Water for Crop Production “.

8. Drainage Master Plan of Pakistan, WAPDA (2004) and Drainage Vision – 2025 Pre-Feasibility Study WAPDA.

pdfMachine trial version

BIO-DIESEL PRODUCTION JATROPHA PLANTATION PROJECT IN PIPELINE WITH SUPPORT OF KOREA

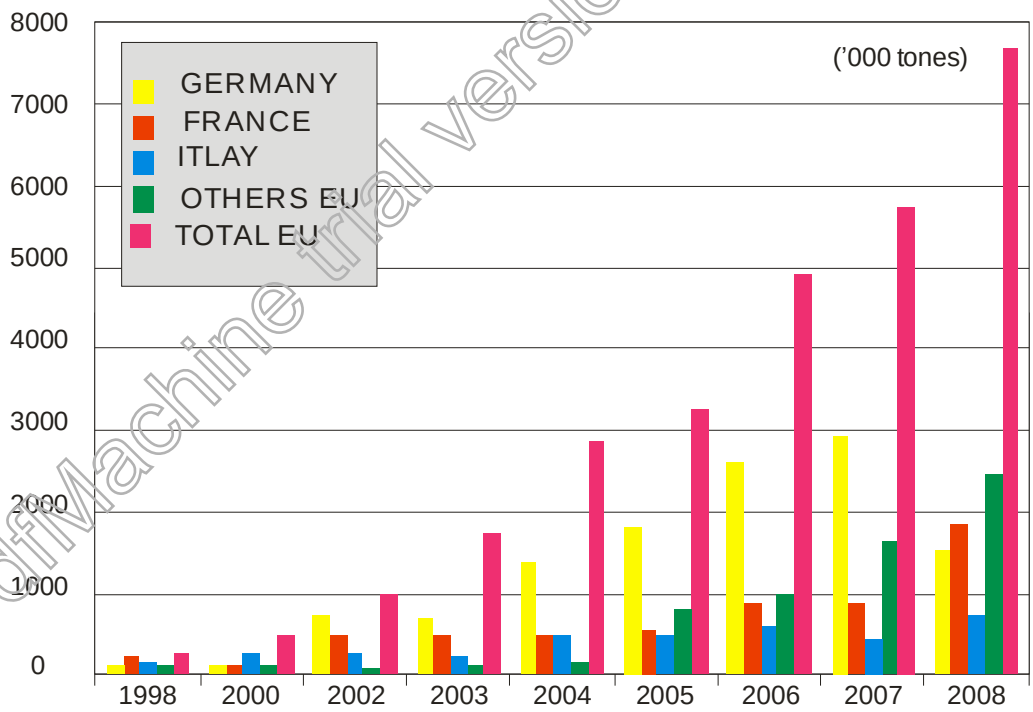
To overcome the shortage of petroleum products and to reduce huge import bill, the government plans to present a pilot project "Jatropha Plantation and Production of Bio-Diesel" with estimated cost of $1.674 million (Rs.133.949 million). It gives income of $569 per hectare per year, while the bio-diesel production plant will give income of $21957 per year

The government of the Republic of Korea would assist the government in initiating the pilot project through provision of $1.464 million (Rs.117.189 million) while the remaining amount Rs.16.760 million would be provided by Zarai Tarqiati Bank (ZTBL) borrowing.

The Pilot Project will comprise cultivation of Jatropha on at least 200 hectares of land by farmers and setting-up of a bio-diesel production unit. In this way, the farmers would earn from Jatropha farming, farm worker would have employment, small rural enterprises would sell or purchase the seeds. Small-scale industries would grow for oil production; diesel fuel production would further provide business opportunities. Bio-products like press-cake would be traded by villages, energy employment and earning would go together and marginal lands and cultivable wastelands would be utilized.

Summary of the project was sent to the Planning Commission for concept clearance so that the work on it should be processed further with donor agencies.

EUROPEAN UNION (EU) AND MEMBERS STATES' BIO-DESIEL PRODUCTION



pdfMachine trial version

The ZTBL can play a vital role in promotion of alternate energy source through increased lending for cultivation of crops like Jatropha, Caster, Salicornia, Sukhchayn and Algae as raw material for production of bio-diesel. To start with the pilot, the ZTBL will promote plantation of Jatropha trees over 200 hectares. Jatropha by and large is a drought resistant perennial growing well in marginal and poor soils. It is easy to establish, grows relatively quickly and lives producing seeds for 50 years. The seed contains oil content up to 37%, while the Kernel consists of oil up to 60%. It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine. This can be transformed into bio-diesel fuel through etherification.

The Pilot Project would complete in 60 months time period. Initially the beneficiaries would be the farmers of Mianwali, Bhukkar, Khushab, Bahawalpur and Rahim Yar Khan districts where plantation of Jatropha on 200 hectares of land will be made. The farmers will be given buy back guarantee of Jatropha seeds on a pre-determined price, which will ensure that the farmers should get a fair return on plantation of Jatropha trees. Over all goal of the project is to increase income of the farmers and rural poor with the ultimate objective of alleviating poverty in rural areas and agriculture sector. It is supposed that after 5 years, the government would be able to get medium yield of about 4 kilogram seeds per tree per year for production of bio-diesel.

The proposed starting of the pilot project is January 2010 and the estimated end date is December 2014. From 6th year onwards of the project, plantation will give income of $569 per hectare per year for 50 years, while the bio-diesel production plant will give income of $21957 per year.

The world today is facing a great challenge to meet the growing energy demand, which is likely to double in the next 20 years. Pakistan is among those developing countries where the need to tackle the challenge is great. Its energy demand is projected to reach 129 million tones of oil equivalent (MTOE) in the next 15 years.

Ensuring availability of useable and affordable energy is, therefore, the bedrock of Pakistan's current and future development. In recent years, the energy demand has increased sharply in the country, while the supply of energy, on other hand has remained far too short to match growing demand because the existing resources could not be sufficiently explored and expedited despite being a high priority item on the economic agenda of the government.

The growth of this sector remained slow due to many factors such as inadequate institutional framework, financial constraints, sky-rocketing oil prices, high risks, low interest of private sector, heavy cost and complex character of hydrocarbon development. To address the issue of demand-supply gap the government is working on many fronts, including promotion of efficient use of energy and acceleration of current programs of alternative energy development, particularly production of bio-diesel and generation of electricity through solar energy and windmills.

The sources told this scribe that the ministry of environment, government of Pakistan has been assigned the indicative target to replace 5% of annual diesel consumption with bio-diesel by the year 2015 and 10% by the year 2025 by the ECC of the Govt.

Courtesy : Ijaz Kakakhel

pdfMachine trial version

FOREWORD
By
Engr. Ch. Ghulam Hussain*
ON
WORLD WATER DAY MARCH 22, 2010

The earth, we live on, was created by Almighty Allah around 4.54 Billion years ago according to Wikipedia and every living thing on it was made from water. And what an undeniable testament that all life whether human, aquatic, avian or botanic can be seen humming and throbbing only there where is water otherwise it is nonexistent.

Since its creation with sparse population, availability of water posed no problem to the life and all went well. Little wonder the savants and the selfsame think-tanks could hardly be expected to foresee catastrophic development of water shortage poised to threaten the existence of life on earth.

Now that the population on earth has grown to astronomic proportions, the water availability, which could not keep up with the genuine demand, is rapidly becoming scarce. It is over 1430 years now that Almighty Allah revealed in the Holy Quran that He made all living things from water (SURA Al-anmbia verse 30). Accordingly, there would be no life when there is little or no water. Struggle for existence of life would invoke wars between nations and such an eventuality foreseen in immediate future between Pakistan and India is fraught with heavy human and infrastructure losses.

However, the Nations of the world discussed this acute and frightening issue in the year 1992 as to how best tap, conserve and manage the usage of available water resources in an orderly and viable manner for the living creatures.

As a result, in 1992 during the “United Nations Conference on Environment and Development (UNCED)” in Rio de Janerio the comity of nations took the initiative for observance of World Water Day starting on 22nd March of every year as of 1993.

Further, UNO during its 58th Session declared the period from 2005-2015 as the international decade for Action “Water for Life”. Starting on World Water Day – 22nd March 2005 it marked the start of it. The water for life decade 2005-2015 is expected to boost the chances of achieving international water goals including

pdfMachine trial version

*Secretary, Pakistan Engineering Congress & Managing Partner, National Development Consultants (NDC).

those in UN millennium declaration. The aspects of available water resources, their conservation and usage are manifold. Every Nation is engaged in addressing the issue in the perspective of its respective requirements. Seminars / Symposia on the topic proposed by UNCED are held every year on this Day where technical papers on various aspects of the issue are presented and discussed to enlighten and educate the engineers, scientists and the public at large. Such topics are manifold and can be on various aspects of water usage.

The symposium on World Water Day for the year 2005 was held on 22nd March by Pakistan Engineering Congress in collaboration with Water and Power Development Authority (WAPDA). Six technical papers by eminent engineers and experts were then presented on the diverse fields from Large Dams to drinking water and related public hygienic care.

At the World Water Day on March 22, 2006 eight technical papers were presented which included "Water as Instrument of peace, the vision of Indus Waters Treaty 1960". In this paper Engr. Jamaat Ali Shah, Pakistan Commissioner for Indus Waters dwelt at length on the pros and cons of the historical treaty where three Eastern Rivers of the system i.e. the Sutlej, the Beas and the Ravi were apportioned to India and the remaining three western, the Chenab, the Jhelum and the Indus fell to the lot of Pakistan with the proviso that India could use run of the river water at these rivers for generation of Hydropower. Quite arbitrarily and in sheer disregard of the aforesaid proviso, India has constructed 62 Dams for water conservation and diversion or exploitation of releases to meet its own ends and to cause huge devastation of irrigated lands of Pakistan.

At World Water Day 2007, the Secretary Pakistan Engineering Congress in his key note address drew the attention of the audience about the unpleasant yet undeniable staggering figure of the shortage of water availability the world over. Two out of three people in the world, he said, would face water shortages by 2025. But the burden of water related problems would fall most heavily on the poor, living in the rural areas.

In the context of Pakistan, he said, development of water resources is essentially required for the sustained economic development. He went on to say, that storage capacity of reservoirs constructed on the Indus and its tributaries provided overall increase of about 22 percent in the canal supplies as compared to the pre-dams scenario. However, due to progressive sedimentation of these reservoirs reduction in the storage capacities of these dams was anticipated to be over 6.03 MAF by the end of this year which is equivalent to the capacity of one mega reservoir.

PDFMachine trial version

On the other side the current population of about 150 million was projected to become 220 million in 2025. Hence, without building another major storage dam by the year 2015, it would not be possible to feed the growing population. Accordingly, immediate measures, he said, would be required to start construction of Kalabagh, Basha and Akhori dams. Kalabagh Dam has unluckily been shelved by the Government of Pakistan under anti-nationalist Political Exploiters ; others Dams are no where in sight as yet.

Eight technical papers on the topic of combating water scarcity were presented and discussed. Most important was the one presented by Usmane Ghani Joint Commissioner (Pakistan Commissioner for Indus waters) on coping with water scarcity and Indus waters treaty vision. He dwelt at length on the signing of the treaty and highlighted major issues that have cropped up between Pakistan and India which are bringing to bear serious repercussions due to arbitrary mis-appropriation of waters of three western rivers by India.

In the year 2008, nine technical papers were presented and discussed on the subject of waste water and solid waste treatment and recycling for combating environmental and public health hazards etc.

In the year 2009 World Water Day was observed on March 28, 2009. The theme of the Seminar was 'Transboundary Waters' which incidentally was considered most relevant of all the Seminars held thus far in the context of Indo-PAK conflict on arbitrary and irrational hold-up of the Chenab and the Jhelum waters by India. Six very convincing and logical papers on the subject were presented and deliberated.

In the year 2010, the World Water Day was convened on March 22, 2010 at Mashhadi's Hall of Pakistan Engineering Congress. The theme for the Seminar was "Communicating Water Quality Challenges and Opportunities". Ten Technical Papers were presented by learned speakers on the related subject at the event. In his address of Welcome, the President of the Engineering Congress discussed about the rising Global temperature which by the end of 21st Century would increase from 3 to 3.2 degree Celsius and melt the great Himalayan glaciers and cause catastrophic consequences in the shape of:

- Flooding.
- Drastic reduction in river in-flows resulting in food shortages, famines, starvation.

pdfMachine trial version

- Prolonged electricity outages and the consequent over dwindling living standards.

- Drastic reduction of Agricultural yields and consequent food shortage, starvation and throwing millions of people much below poverty lines. Besides, the oceans would rise unimaginably engulfing vast areas of the earth. This is another aspect of water losses which calls for immediate and sustained preventive measures to check greenhouse gases emissions the world over.

Papers published in this volume are open for written discussion where Engineers and Scientists are invited to take part. This is an important issue which merits continuous attention of the professionals as well as decision makers to absolve themselves of their obligation towards posterity. Depending upon the volume of discussion on papers received, the congress would also like to publish a discussion Volume in the intervening period 3 months before the next "World Water Day" on March 22, 2011.

To meet with the increasing demand from the Engineering Congress Members and Scientists, this Volume is being published in a befitting and decently bound booklet for distribution amongst them.

pdfMachine trial version

Address of Welcome
By
Engr. Husnain Ahmad
President
Pakistan Engineering Congress
On
World Water Day March 22, 2010
At
"Mashhaddi Hall" of Pakistan Engineering Congress

Honourable Mr. Shakil Durrani Sahib, Respected Scholars,
Executive Council Members,
Fellow Engineers,
Ladies & Gentlemen !

It is the importance of water in the life of individuals and nations that the United Nations Conference on Environment Development (UNCED) held in Rio de Janerio in 1992 declared 22nd March as "World Water Day". Since then, it is being celebrated the world over. At the occasion of World Water Day, experts on "Water Resources" speak on the Theme & the related issues laid down for that particular year.

The theme for this year is:

"Communicating Water Quality Challenges and Opportunities".

Ladies & Gentlemen !

The Allah Tabarak wa Ta'ala, Himself through numerous verses in the Holy Quran signifies about the crucial role played by "Water" in the socio-economic life of mankind.

"And He is Who created the Heavens and the Earth in six days and His Throne was on water" (Sura Hud).

"He showeth you the lightening for a fear and for a honour sendeth down water from the sky and thereby quincheneth the earth after death" (Sura Rome).

"And have sent down from the raining clouds abounded water thereby to produce gram and gardens of thick foliage" (Sura An Naba i.e. Tidings).

pdfMachine trial version

Ladies and Gentlemen !

Let me begin by drawing your kind attention towards the importance of Climate Change on Water Resources:

- Environmental experts have visualized that unless the present levels of **"carbon emissions"** are drastically reduced, there will be earth-shattering 2-degree-celsius increase in global temperatures by 2050. The "Copenhagen" formulations will even if scrupulously implemented would arrest the increase at the most by 1-degree Celsius.

- A second study by sustainability institute of USA reveals that "Copenhagen" proposals will possibly result in 3.9 degree increase in world temperatures by 2100.

- A German study reveals that even if "Copenhagen" proposals are fully implemented, there will be approximately 3.2 degree Celsius increase in temperatures by 2100.

  The UNEP's chief spokesman Nick Nuttal is reported to have said,

  "It becomes increasingly difficult to achieve reduction and increasingly costly if you wait".

The leading greenhouse gas emission polluters & further predictions in their respect are given below:

		Million Metric Tons of CO2		
		2007	**2020**	**2050**
1	**China**	8106	11,292	16,232
2	**U.S.A**	6087	6308	7098
3	**European Union**	4641	4804	6912
4	**India**	1963	3194	5027

pdfMachine trial version

Pakistan ranks amongst lowest greenhouse gas emitters on the world (135th), but in terms of impacts and vulnerability it ranks in the top 20 category.

Ladies & Gentlemen !

The repercussions of 2-degree temperature increase are visualized as under:

i. Most parts of Amazon rain forest will stand dried / burnt throwing-out millions of tons of extra dioxide.

ii. Greenland's ice will melt away thereby raising the sea levels by as much as seven (7) meters submerging low lying coastal areas, uprooting millions of people with devastating economic fall-out, altogether disappearance of some of the islands.

iii. Accelerated Himalayan Glaciers melt. The Himalayas Glaciers (12000 to 15000 occupying 500,000 Sq. Km) are receding fast.

- A study involving 1387 selected glaciers reveals 16% reduction in area since 1962. (over a 48-year period).

- Another study including Pindari, Gangotri & Dokriani glaciers show the annual retreat by 5 to 49 meters.

The Himalayan Glaciers are the source of sweet water to Asia's seven (7) river systems including:

- Indus
- Yangtze
- Mekong
- Ganga
- Brahmaputra

A critical study of the data reveals that if stringent measures are not put in force to check the expected temperature increase visualized at 3 to 3.2 degree Celsius by 2100 (next 90 years).Himalayan glaciers would disappear by 2300. However, the crux of the matter is that the catastrophic consequences are manifestly imminent in the shape of:

- Flooding.

pdfMachine trial version

- Drastic reduction in river in-flows resulting in food shortages, Famines, Starvation
- Prolonged electricity outages & the consequent falling living standards.
- Agricultural yields would stand drastically reduced in global terms especially creating food shortages, starvation and throwing millions below poverty lines.

In a recent statement Dr. Zafar Adeel who is an eminent scholar and a member of United Nations Think Tank Team on water said:

"The impact of climate change on water resources was quite central for a country like Pakistan. The general public as well as the political & policy leadership needs to be fully aware of the challenges, being imposed on Pakistan due to climate change"

The question is why so and where does Pakistan Stand in Water Availability?

Ladies & Gentlemen !

Please have a look at the table which shows the rapid reduction in per Capita water availability in Pakistan.

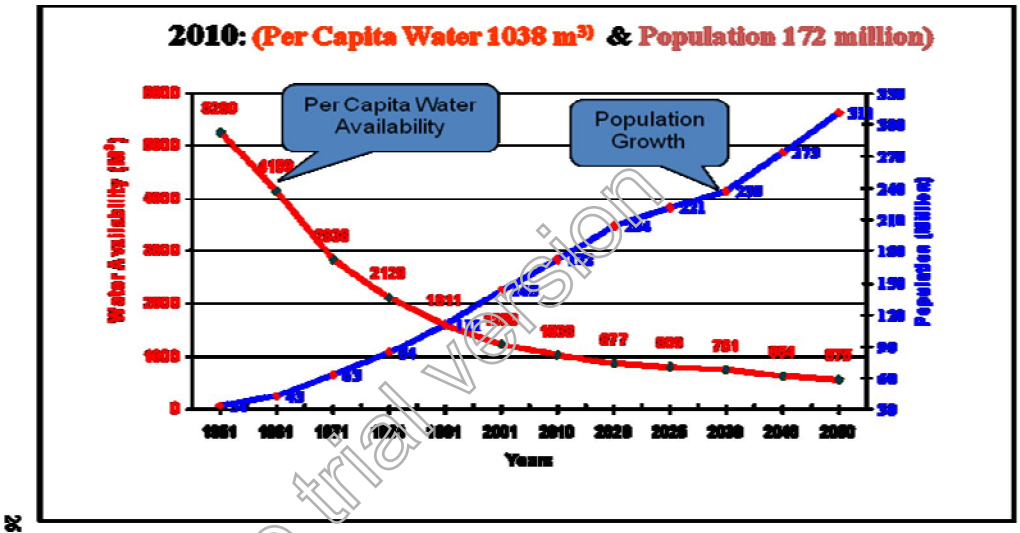
Year	Population (Millions)	Growth Rate (R)	Total Water Availability		Per Capita Water Availability (M3)
			MCM	MAF	
1951	34	0	178840	144.9	5260
1961	43	2.38	178848	144.9	4159
1971	63	3.89	178815	144.9	2838
1981	84	2.72	178836	144.9	2129
1991	111	2.38	178825	144.9	1611
2001	143	2.60	178780	144.9	1250
2010	172	2.10	178584	144.7	1038
2020	204	1.70	178948	145	877
2025	221	1.60	178880	145	809

pdfMachine trial version

2030	238	1.50	178710	144.8	751
2040	273	1.40	178668	144.8	654
2050	311	1.30	178800	144.9	575

In 1951, per capita water availability was 5260 (Cubic Meter) which stands slided to 1038 (Cubic Meter) in 2010 – a very steep and worrisome position. With the country's population increased from 34 million to 172 million and visualized at 311 million by 2050, the country will be a severely water scarce country with per capita water availability reduced to a miserable 575 (Cubic meter) an alarming and distressing scenario indeed.

A diagrammatic presentation would make the position even more glaring for an understanding mind.



What are the reasons behind this entanglement and what is in store for us in future.

The people at the helm of affairs of the country as well as the planners of socio-economic development schemes without any exception have shown apathetic negligence towards building-up of water reservoirs. Almost 3- precious decades have been wasted away in political wranglings about construction of kalabagh Dam, an engineering matter sacrificed at the altar of political egoistic behavior. What is even more incomprehensible is the non-construction of other Dams now belatedly taken-up and which will take 10-16 years to bear fruit.

CamMachine trial version

- Diamer Basha
- Dasu
- Akhori
- Kurram Tangi & Munda

And let me also share the consequential effect in a comparative manner, if no rains occur over a prolonged period. To quote Engr. Mumtaz A. Khan:

- America has water storage enough for a number of years.
- China has 200 days water storage.
- India has water enough for 170 days consumption
- Pakistan has water storage enough for barely 30-days.

A disappointing & an enigmatic situation and in the meantime 35 MAF water is wasted away untapped to the sea.

Decades back world renowned veteran Engineer, Engr. S. S. Kirmani (Late) bluntly told that if proper attention is not given to storage and conservation of water , the country would not have enough water for domestic, agriculture and industrial consumption and now due to our ostrich like attitude, we have come to a dead end & do not find an escape route.

Pakistan Scenario

Ladies & Gentlemen !

Let us now have a bird's eye view of access to water etc in the country:

- Compared to 93% MDG target by 2015 an overall 66% of the country's population has access to safe drinking water.
- 85% people of urban areas have facility of safe drinking water.
- Out of 30,000 villages about 1/3rd villages (55% of the population of these villages) have access to safe drinking water. Remaining population of 20,000 or so villages have no such facility.
- 25% of adults and 40% children are exposed to water-borne diseases.
- Ground water should normally be less exposed to bacteriological contamination than surface water. However, even ground water is becoming un-safe due to leakage of pipes, un-treated municipal wastes (both waste water & solid waste) un-checked use of pesticides, nitrogen, fertilizers, industrial wastes etc.

pdfMachine trial version

- Tap water availability position is:
    - 62% Urban
    - 22% Rural (a dismal position)
    - 36% overall
- Studies of selected cases reveal that most of the people (almost 80%) are exposed to use of un-safe drinking water.

- Streams & Rivers have been heavily polluted due to defective, out-dated & inadequate sewage treatment facilities and dumping of chemical, agriculture waste. Even lakes like “Mancher” have been polluted to the brink.

- Due to over-mining of water through tubewells and the declining re-charging of underground water reservoirs, the water table has fallen by 40-50 feet.

Water Quality Scenario

Ladies & Gentlemen !

Water is one of the most precious commodities for sustenance of life. Whilst abundant water is available around us, fresh water resources have depleted at an alarming rate. Changes in weather patterns are adding more challenges to our experts of water resources management. Pakistan is rapidly becoming a water deficient country.

Excessive ground water exploitation (the number of tubewells is touching 1-million mark) by industry and agricultural sectors have forced untreated industrial and municipal waste water into our fresh water resources. Care free attitude towards water by everyday rising population need comprehensive measures and awareness about water re-use and re-circulation. Non-availability of dams is costing us in billions of rupees annually in terms of ground water pumpage for irrigation. India’s building of dams is further aggravating our water resources situation. In order to develop sustainably, we must involve U.N in resolving water issues between us and our neighbors. Any further delay would force us into a water war rather than long waited peace that is so overdue.

On one hand we are losing our fresh water resources and on the other hand we are destroying the quality of the available resources by indiscriminate discharge of all kinds of waste water into our rivers, reservoirs and fresh water streams. Most of the hospital beds in our country are occupied by patients of water related

pdfMachine trial version

diseases (loss of 0.6% to 1.44% GDP). Hepatitus B and C which were almost non-existent have become an every family's affair.

Pakistan is confronted with all kinds of water related problems. Good quality raw water is only available underground which requires energy resources for pumping. Most of the water supply agencies have poorly trained and carefree manpower. Supply networks are old, rather expired, and occasionally cross-linked with sewerage lines. A system of water quality monitoring at the consumer end is totally non-existent. High Arsenic content in ground water in the southern belt is already taking its toll. Experts have reported high Arsenic in Lahore's groundwater. Menace of high nitrates is spreading around most of our rural areas. Shortage of Iodine is spreading Goitar in the outer fringes of Pothohar region. Earthquake of 2005 has modified groundwater quality in most of the earthquake struck areas. Many springs have disappeared. Surface water quality has deteriorated to a very poor level. Water filtration plants installed could have helped improving drinking water quality but very poor maintenance is taking away all the good-work and with the passage of time these filtration plants are becoming sources of biologically polluted water. In fact, such a temporary arrangement was bound to fail. All around the developed world one will hardly find such a solution for supply of safe drinking water to large communities.

The only answer to our safe water supplies is the standard treatment plant involving coagulation, flocculation, sedimentation, filtration and disinfection. Every water treatment facility must be equipped with a trained water quality monitoring team and a decent laboratory. All existing water supply networks must be thoroughly examined for leakage and cross-contamination. Expired lines must be replaced with fresh lines. Good quality, high strength PVC pipes, made up of food grade resin, can be used for supply lines. These pipes have smooth inner surface and offer low head-loss when compared with traditional G.I pipes. Water meters at the cost and security of every household would help returning the cost of such endeavors. In fact, if the cost of medical bills for water related diseases is compared with the cost of these conventional plants and supply networks, the latter will outweigh the former within a period of less than two years.

A clean drinking water for all (CDWA) project launched several years back envisaged setting-up of 6626 filtration plants all over the country. This could have gone a long way, however, only 822 filtration plants have been installed.

Availability and Quality of Water in Punjab

Ladies and Gentlemen !

pdfMachine trial version

Punjab can be divided into four major zones on the basis of drinking water quality:

a) Sweet zones
b) Brackish zones
c) Barani zones
d) Mixed (brackish / barani) zones

The quality of underground water depends on geo-formation of the zone and is generally manifested in terms of Total Dissolved Solids (TDS).

- Predominantly Water Scarce Barani Districts 3 Nos
- Predominantly Brackish Districts 11
- Sweet Water Districts 13
- Mixed (Brackish Barani) Districts 7

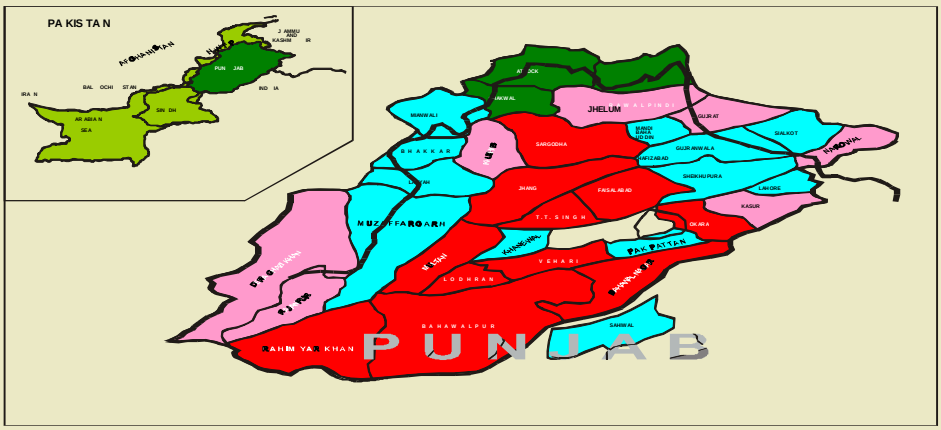
34 Nos

The below given table and diagram will make the matters all the more clear:

Predominantly Water Scarce / Barani Districts	Predominantly Brackish Districts	Sweet Districts	Mixed (Brackish/ Barani) Districts
Rawalpindi	Faisalabad	Lahore	D.G. Khan
Attock	T.T. Singh	Sheikhupura/Nankana	Rajanpur
Chakwal	Multan	Gujranwala	Khushab
	Jhang	Sialkot	Jhelum
	Lodhran	Hafizabad	Gujrat
	Bahawalpur	M.B. Din	Narowal
	R.Y. Khan	Bhakkar	Kasur
	Okara	Pakpattan	
	Sargodha	Mianwali	
	Bahawalnagar	Layyah	
	Vehari	Muzaffargarh	
		Khanewal	
		Sahiwal	

pdfMachine trial version

Ground Water Quality in Punjab



Brackish Districts
Barani Districts
Mixed (Brackish / Barani) Districts
Sweet Districts

Recommendations:

- There is no substitute of big dams for conservation of water & these need to be completed in record time.
- Presently drinking water availability is about 4.5 MAF. If MDG goals are to be met and drinking water made available to the urban and rural population, water supply would have to be augmented by additional 4-MAF.
- Small Dams (no substitute for big dams irrespective of the numbers built) need to be constructed. In POTHOHAR Plateau 15. Such dams were built (another 5-dams nearing completion). It has created 91746 AFT water storage bringing about 29760 acres of culturable commanded area. It is heartening that small dams are being constructed in all provinces.
- Responsibility of supplying drinking water rests with Tehsil Municipal Administration (TMA's). However, these need to be technically & financially empowered (presently highly deficient).
- Direct supply of water from the ground through tubewells is open to serious health hazards. It should be through "overhead" water tanks and supplied after chlorination & treatment.
- Fiscal measures are required to be undertaken to ensure assured supply of safe drinking water in adequate quantities and at a price that at least covers the cost.
- For conservation of water metered supply should be resorted to in all cases.
- Experts have suggested adoption of the following measures to avoid wasteful use of water:
  i. Hotel industry be encouraged to install ultra-low flow toilets.
  ii. High efficiency washing machines be introduced.
  iii. Planting of low water / drought resistant plants in lawns / gardens.
- Underground water levels have gone down alarmingly due to over-pumping of water by tubewells as well as the set-back to the re-charging of underground aquifer. Govt. of Punjab plans to develop a lake over 500 acres of dried-up bed of sutleg river. It aims to bring 120,000 acres of land

pdfMachine trial version

under-cultivation besides checking the menace of arsenic substances & brackish water. Such like schemes ought to be launched wherever possible in all provinces.

- India should be made to realize that Pakistan will not allow violation of Provisions of Indus Basin Treaty – 1960. The case in point is the "Kishanganga" Project that would significantly impact "Neelum Jhelum Hydro-Electric Plant" besides having additional environmental impacts.

PAKISTAN ZINDABAD

pdfMachine trial version

Inaugural Address
By
Mr. Shakil Durrani
Chairman
Water and Power Development Authority
On
World Water Day March 22, 2010
At
"Mashhaddi Hall" of Pakistan Engineering Congress

President Pakistan Engineering Congress, Distinguished Guests, Participants, Ladies and Gentlemen!

Assalam-o-Alaikum !

1. I deem it an honour and a duty to deliver the inaugural address to this concerned gathering on the occasion of World Water Day being celebrated with the theme "Communicating Water Quality Challenges and Opportunities" organized by Pakistan Engineering Congress in collaboration with WAPDA.
Let me begin with a cliche.

2. Water has a pivotal position in all development activities for its enormous importance in food security, livelihood, environment, economics, power generation and in fact life itself. However, the quality of water whether for use in agriculture, municipalities, drinking, household and in industry acts like a quality multiplier. So it is not only the quantity but the utility which determines the levels a society or a country reaches. This can be appreciated from the fact that out of total available water on the earth, only about 3 percent is directly usable. And of the fresh water, 69 percent is locked up in ice caps and glaciers primarily in Antarctica and Greenlands, 30 percent is stored in ground water reservoirs and only a tiny quantity is available in fresh water lakes, rivers and streams.

3. The water situation in our country as you are aware, is facing both quantity and quality issues. The water availability at the time of independence was 5260 cubic meter (M^3) per capita which has reduced to 1,038 M^3 in the year 2010 and will further reduce to 809 M^3 in 2025. Soon we would be a water starved and not just a water stressed country. Despite these critical shortages, we in Pakistan remain extravagant in its use. Our biggest concern should be the surface irrigation with very low efficiencies and considerable waste. Our farmers are unaware of the benefits of modern irrigation techniques and the responsibility for this primarily lies with Government. Similarly our standards for drinking water and increasingly of irrigation water as well leaves much to be desired.

Machine Trial Version

4. Pakistan has 75 million acres (MA) of land suitable for agriculture. However, by making the additional water available through more storages and high efficiency irrigation system, nearly 20 million acre of additional land can be brought under cultivation.

5. Another aspect which needs attention at the national level is the water which escapes to sea and is more than the requisite amount. Between the period 1976-2009 average annual flows below Kotri have been 31.5 MAF. The flows during the last 10 – 15 years have often been lower. What is heartening is the realization that we have the land and the water potential not only to feed us but to generate surpluses as well.

Ladies & Gentlemen !

6. In the years ahead we need to concentrate upon the following five priorities for balanced growth and equity:

i) Development of additional reservoirs.

ii) Increasing irrigation water efficiency through modern irrigation modes like drip and sprinkler system.

iii) Ensuring provision of clean drinking water.

iv) Treatment of saline water for use in agriculture and fishery.

v) Recycling of urban and industrial waste water for different uses.

7. These five priorities could be achieved efficiently if only we cost our irrigation and drinking water economically. Currently, for instance only about 25% of O&M charges for irrigation water are actually recovered as Abiana. This recovery does not include the capital costs of the storages and channels. No wonder we are so profligate. For providing drinking water to the disadvantaged sections, an element of intervention by the State in the form of subsidies would be required for some time. For the rest of the population and especially for the large farmer it is important that the real cost of water is recovered from them.

8. As far as increasing storage is concerned, I would also like to mention that after the creation of Pakistan, only 3 Mega water storage reservoirs – Mangla, Tarbela and Chashma have been constructed. Their storage capacity has been reduced by 28% due to siltation. The daily silt deposit in Tarbela is nearly half a million tons. With this reduction in storage capacity, it was felt necessary to start construction of new storage reservoirs. In this regard WAPDA has been executing many projects for the development of surface water resources on fast track basis. These include the Mangla Dam Raising (3 MAF) and Gomal Zam

PDFMachine trial version

(0.89 MAF). The big one at Diamer Basha Dam (6.4 MAF), Kurram Tangi Dam (nearly 1.0 MAF) and some other projects are currently in various stages of planning and implementation. Diamer Basha Dam Inshallah shall be started early next year. A dozen Small and Medium Dams are also in different stages of planning and implementation in all the four provinces with potential of storing 2.5 MAF and will be completed by 2013. Studies for storages and other sites are also underway by WAPDA.

9. Wastage in irrigation needs rectification by adopting high efficiency irrigation systems like drip and sprinkler irrigation. In drip irrigation, there could be a saving of upto 50% of irrigation water and also a concomitant reduction in the use of fertilizer. The initial costs are high at about Rs.50,000 to Rs.70,000 per acre but then water is even more valuable. In any case the costs can be recovered in a few years. The flood irrigation system requires 3,470 M^3 of water per crop acre whereas drip irrigation system requires 1,590 M^3 of water per crop acre and sprinkler requires 1,690 M^3 of water per crop acre. Drip can save 1,880 M^3 of water, whereas, sprinkler can save 1,780 M^3 of water per crop acre. A comparison of flood and drip irrigation is shown in the slides. By adopting high efficiency irrigation system, the additional area can be brought under cultivation with the saved water.

10. The water channels pollution is frequently associated with the disposal of untreated effluents from municipal, industrial and agricultural wastes. The natural streams are always considered as an easy way to dispose off many kinds of effluents. The psychology behind this practice is that the wastes are washed away and are not visible at dumping sites. Besides this, indiscriminate pumping of groundwater is causing over mining which is enhancing salt water intrusion and polluting the groundwater.

11. WAPDA is presently undertaking a study for treatment of saline water of the RBOD-I. Our consultants would soon submit the initial recommendations for treating water for a pilot project of 40 cusecs. The costs are doubtlessly high but their long term benefits are more alluring. Imagine, if we can save 10 MAF of saline and polluted water and use this for agricultural purposes. This adds a Tarbela Dam equivalent reservoir for us.

Ladies & Gentlemen !

12. We have no more time for sterile discussions and debates; now is the time to act. Planned usage of available resources and developing a time bound action plan are central to our survival. Organizing and engaging local communities to help themselves through practical schemes and creating awareness among

pdfMachine trial version

masses about the precious resource scarcity is need of the day. For managing water scarcity, WAPDA is recommending adoption of high efficiency irrigation system in both public and private sectors. Each province needs to earmark at least 10,000 acres next year for drip and sprinkler irrigation through PSDP as pilot project in collaboration with private sector. Credit facilities for such innovative programmes are urgently required. Distinguished individuals like yourselves and organizations like the Pakistan Engineering Congress could act as agents of change in this regard.

13. In the end, I would like to thank Pakistan Engineering Congress, WAPDA and representatives from other organizations for their participation and commitment to the goal of the World Water Day. We should not just be observing the World Water Day as a one-off event but move forward to celebrating it in the years ahead through achieving our objectives. Your contributions would certainly be helpful in better understanding the water quality problems; its magnitude and solution. I would suggest that the recommendations of the seminar should be sent to all the federal and provincial institutions dealing with water.

Thank you and Allah Hafiz

PAKISTAN ZINDABAD

pdfMachine trial version

PREVALENCE OF *ESCHERICHIA COLI* WITHIN PUBLIC DRINKING WATER SUPPLY IN 1-8 SECTOR, ISLAMABAD

By

Sajida Rasheed, Imran Hashmi* and Sara Qaiser

Abstract

Insufficient treatment of surface waters for the drinking water supply, malfunctioning of sewage collection systems, and defective water distribution pipelines have led to contamination of potable water by fecal *coliform* and other pathogenic bacteria. Sector I-8 of Islamabad was monitored for the physicochemical parameters as well as biological contamination to track the microbial contamination and residual chlorine throughout the water distribution network. Samples were collected from source, underground tank and end point users, i-e., houses were analysed for total chlorine, free chlorine residual, chloramines, *total coliforms, fecal coli forms,* total dissolved solids (TDS) and turbidity. The value of total chlorine was estimated to be 0.13 mg/L; free chlorine was 0.09 mg/L, monochloramine of 0.04 mg/L and dichloramines of 0.03 mg/L. From the analysis result it is clear that the temperature of the water samples tested varied from 25.8 to 26.7 at *Station # 4* and *3*. The values of pH fluctuated from7.10 to 7.62 at *Station # 1* and *4* respectively. The value of TDS was lowest at *Station # 4* with values ranging from 332 to 354 mg/l with mean value of 339 mg/L while maximum value was obtained at *Station # 6* with mean value of 368 mg/l. Conductivity values were found varying in between 683 to 749 µS/cm at *Station # 4* and *6*. All the parameters were within WHO standards of drinking water quality. Highest value of turbidity was obtained at *Station # 2* with mean value of 1.27 NTU while lowest value was observed at over head tank at I-8 with mean value of 0.34. The value of total chlorine varied from 0.05 mg/L at *Station # 3* to 0.13 at *Station # 1.* Free chlorine residual was also detected in the system with average values varying from 0.02 mg/L at *Station # 3* to 0.09 at *Station # 1.* Microbial analysis of drinking water samples revealed that fecal contamination at *Station # 3* with MPN /100mL of 16.1, at *Station # 5* and *7* MPN/100 mL was 6.9 and at *Station # 8* MPN/100ml was 5.1. While at the rest of the stations MPN/100 ml was <1.1. The maximum SPC counts were observed at *Station # 3* with values ranging from 81 to 370 CFU/mL with average value of 267 CFU/mL. At the rest of the stations SPC counts were below countable range. So from the analysis it revealed that water sample from *Station # 3* was highly contaminated. The water samples collected were also analyzed for TOC. The analysis results were alarming as high amount of TOC was observed at all of the sampling stations which were above standards of treated drinking water i.e., above 2 mg/L. The values were found to be ranging from 7.67 to 22.57 mg/L. The main water supply had a TOC value of 11.22 mg/L. The routine monitoring of the water distribution network is strongly recommended for provision of safe and clean potable water to public.

Machine Trial Version

---

*Institute of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering, National University of Sciences and Technology (NUST), Sector H-12, Islamabad, Pakistan.

Keywords: *Escherichia coli,* Chlorination, Chlorine residual, Coliform, Microbial counts, Monitoring, Drinking water.

1. Introduction

Protection of public health from pathogenic contamination in drinking water infrastructure is a critical component in the operation of a community drinking water system (Helbling and Van Briesen, 2008). Reported pathways of accidental pathogenic contamination in the distribution system include cross-connections with non potable water sources (Liang et al., 2006) and intrusions via waterline materials that are aged and structurally compromised

The occurrence of *coliform* bacteria in otherwise high quality drinking water has been a nemesis to the drinking water industry (Le Chevallier et al., 1988). Transmission of pathogens with drinking water is a widespread problem, which affects not only the countries with low hygienic standards but the industrialized countries as well (Schoenen, 2002). *Escherichia coli,* a member of *coliform* bacteria, is a commensal bacterium of the intestinal tract of humans and various animal species. Among the many harmless strains, pathogenic isolates exist; and such strains can be harmful, especially for children (Balmer *et al.*, 2007). Their presence in drinking water clearly shows fecal contamination (Ram *et al.,* 2009) and indicates a possible contamination of enteric pathogens (Min & Baeumner, 2002). Clinical manifestations range from asymptomatic excretion, through mild non-bloody diarrhea to hemorrhagic colitis and severe complications as hemolytic uremic syndrome (HUS) with acute renal failure, sometimes resulting in death (Schets *et al.*, 2005).

Waterborne outbreaks associated with consumption of faecally contaminated drinking water (Licence *et al*., 2001) and recreation in or consumption of surface water contaminated with faeces have both been reported. Drinking water from private water supplies is often only partially treated or is used untreated. Particularly in rural areas and in periods with heavy rainfall, insufficient protection of wells can lead to contamination. Contamination originating in distribution systems is of particular concern because their spatial distribution could result in widespread contaminant propagation and affect the health of large, dispersed populations.

Chlorination is the predominant disinfection method applied in water and waste water treatment due to its low cost, ease of application, and ability to inactivate a wide variety of pathogenic microorganisms (Donnermaire and Blatchey, 2003). The effectiveness of chlorine as a germicide is a result of chlorine's powerful oxidizing action. Its addition to drinking water has greatly reduced risk of waterborne diseases. I addition, protection of public health from pathogenic contamination in the distribution system is provided by the maintenance of a disinfectant residual and chlorine has its residual effect in the form of chloramines. Chlorine residuals of drinking water have long been recognized as an excellent indicator for studying water quality in the distribution network (Lienyao *et al.,* 2004). For more than a century, the safety of drinking water supplies has been greatly improved by chlorine treatment. When properly designed and operated, the process is well-developed, inexpensive, and efficient (Shang and Blatchey, 2001). Due to these properties, chlorine will remain the most commonly used drinking water disinfectant.

Online Machine Trial Version

Beside the microbial threat in drinking water, Total organic carbon (TOC) is another issue which should be paid attention. TOC is the amount of carbon bound in an organic compound and is often used as a non-specific indicator of water quality. TOC in source waters comes from decaying natural organic matter (NOM) especially humic acid, fulvic acid, amines, urea and from synthetic sources like detergents, pesticides and fertilizers etc. Some of the contaminants may not be completely removed by treatment processes; therefore, they could become a problem for drinking water sources. The recently issued *Disinfectants and Disinfection By-Products Rule* by the US Environmental Protection Agency specifies maximum total organic carbon levels of 2 mg/L in treated water and 4 mg/L in source water to ensure acceptable levels of disinfection byproducts. TOC value of drinking water supply with chlorination is 4 mg/L (EPD, 2001).

It is important to know the organic content in a waterway because if there is a considerably high content of organic carbon compound in the water to be processed, Trihalomethane (THMs) will develop as a result of chlorine reaction with organic carbon. But the maintenance of chlorine residue is needed at all points in the distribution system supplied with chlorine as disinfectant (Kitazawa, 2006). A quantitative assessment of the risks associated with pathogenic intrusions has shown that protection of public health by maintenance of a disinfectant residual may be insufficient (Helbling and Van Briesen, 2008) leading to regrowth of microbes or their accidental intrusion in the pipelines.

In Pakistan chlorination is practiced at most of the filtration plant as the only mean of water disinfection, and it is supplied to the public using plastic pipes via distribution network. But there is no planned regular monitoring program to assess the water quality of the surface and groundwater bodies, at the treatment plants or in the distribution system except at few major water treatment plants (WB-CWRAS, 2005) which allows episodes of serious bacteriological contamination to go undetected. Pakistan has one of the highest child mortality rates in Asia. It is estimated that water related diseases cause annual national income losses of USD 380-883 million – or approximately 0.6-1.44 percent of GDP (UNDP, 2003).

So The objective of this work was to evaluate the efficacy of free chlorine to inactivate the microbes in drinking water distribution network and bacterial contamination events in drinking water distribution systems and to evaluate their inter ralationships along side with other variables like TDS, turbidity and electrical conductivity etc.

pdfMachine trial version

2. Material and Methods

2.1 On field analysis of parameters:

On field, samples were analyzed for temperature and pH (Hach pH meter sension 1), turbidity (Hach 2100) and TDS and electrical conductivity by Hach meter (sension 5).

2.2 Parameters analyzed in Laboratory:

Microbial and chemical analysis of drinking water was conducted by using following test in laboratory.

2.2.1 Biological Parameters

1. MPN (Most probable Number)

The *total coliform* and *fecal coliform* counts were determined by the MPN procedure given in Standard Methods for the Examination of Water and Waste water (APHA, 2005)

using lauryl tryptose broth (LTB) for the presumptive test and brilliant green lactose broth (BGLB) for confirmation.

To meet the quality standards of the U.S. Environment Protection Agency (US-EPA, 1978) recommended use of the fermentation technique with 10 replicate tubes was performed; each containing 10 ml. Sample was poured in LTB tubes and incubated at 35 ± 0.5°C. Production of an acidic reaction or gas in the tubes within 48 ± 3h constitutes a positive result. The positive tubes were shifted to BGLB and incubated at 35 ± 0.5°C. Formation of gas in any amount in the BGLB tube at any time within 48 ± 3h constitutes a positive confirmed phase. The positive tubes show the presence of *coliform*. For confirmation of *fecal coliform*, the positive BGLB tubes were shifted to EC medium and incubated for 35 ± 0.5°C for 48 ± 3h.Here if gas is produced; it is a positive test for *fecal coliform*.

2. Standard Plate Count-SPC

Standard plate counts (SPC) were also determined as per Standard Methods (APHA, 2005). It is a procedure for estimating the number of live heterotrophic bacteria in water. This test can provide useful information about water quality and supporting data on the significance of *coliform* test results. The SPC is useful in evaluating the efficiency of various treatment processes for both drinking water and swimming pools purposes, and for checking the quality of finished water in a distribution system.

The Pour Plate technique is used on any type of liquefied sample for the enumeration of bacteria. Conditions vary depending upon the type(s) of bacteria being enumerated. Agar is prepared according to standard manufacturer's instruction and then held at 44 - 46°C in molten state in a water bath. Serial dilutions of the sample are prepared (using 0.1 % peptone water) so that following incubation, one of the dilutions will yield growth of 30 - 300 colonies (the ideal counting range) on the agar plate.1.0 ml of the sample or dilution is transferred to a sterile, empty Petri dish. Approximately 15 mL of agar medium is poured into the Petri dish containing the sample. The sample and agar are mixed thoroughly by rotating the plate several times, clockwise, then counterclockwise. When the media has solidified, the plates are inverted and incubated at, 37°C ± 0.5°C for 48 - 72 ± 2 hour.

2.2.2 Chemical parameters:

1. DPD Ferrous Titrimetric Method

Chemical analysis for chlorine residual, free chlorine, monochloramine and dichloramines was carried out using DPD Ferrous Titrimetric method (APHA, 2005). For the detection of free chlorine, 5 ml of phosphate buffer and DPD were placed in a flask with 100 ml sample; development of red color was titrated against standard ferrous ammonium sulfate (FAS). Observation was recorded as soon as the color discharges giving value of free chlorine. For determination of monochloramine 0.5 g KI was added to the above sample and was titrated against FAS. The volume of FAS used gives monochloramine in mg/l. For dichloramines 1 g KI was added in the above sample and similar procedure was repeated after 2 minutes standing at room temperature. Similarly for total chlorine 5 ml of phosphate buffer and DPD was placed in a flask with 100 ml sample along with 1.5 mg KI and was noted after two minutes standing in dark.

pdfMachine trial version

2. TOC analysis

The drinking water samples collected were analyzed by TOC analyzer multi win N/C 30. The determination of the inorganic carbon occurs by injection of the sample into phosphoric acid. The resulting carbon dioxide is degassed from phosphoric acid with the aid of carrier gas and quantified with NDIR, according to the TC determination. The CO2 detector measures the concentration of the CO2 gas generated in the oxidation chamber. This component is critical for precise analytical results, since it directly correlates to the organic carbon content of the analyzed water.

3. Results and Discussion

The aim and objective of the study was to evaluate the efficacy of free chlorine to inactivate the microbes in drinking water distribution network and bacterial contamination events in drinking water distribution systems and to evaluate their inter relationships along side with other variables like TDS, turbidity and electrical conductivity etc.

Sampling was conducted in I-8 sector during August and September, 2008. There are two overhead tanks and a water filtration plant in the community which is supplying water to the public. The water at the over head tank was analyzed microbially and chemically to assess the status of drinking water. The analysis revealed that the water is safe for drinking with value of pH 7.10, TDS of 354 mg/L, conductivity of about 714 µS/cm and turbidity of 1.10 NTU. The value of total chlorine was estimated to be 0.13 mg/l; free chlorine was 0.09 mg/l, monochloramine of 0.04 mg/L and dichloramines of 0.03 mg/L. There was no evidence of fecal contamination in water sample collected from over head tank in all three days of sampling.

From the analysis result it is clear that the temperature of the water samples tested varied from 25.8 to 26.7 ºC at *Station # 4* and *3*. Water temperature is crucial for microbiological water quality. The increase in temperature enhances the disinfection efficiency of chlorine, i.e., pathogen inactivation effectiveness increases as water temperature rises. These results are inline with the study conducted by Bailey & Thompson, (1995) who found out that higher coliform counts were associated with higher water temperatures in the distribution system. It has been observed, that when water temperatures rise above 15°C, the growth of colonizing bacteria in the distribution system increases markedly (LeChevallier *et al.,* 1991; LeChevallier *et al*., 1996; Geldreich, 1996).

Chlorination is also effected by pH. In aqueous solutions with pH 7.0 to 8.5, HOCl reacts rapidly with ammonia to form inorganic chloramines (termed combined chlorine) (US-EPA, 1999) The values of pH fluctuated from7.10 to 7.62 at *Station # 1* and *4* respectively.

The United States Environmental Protection Agency (US-EPA, 1978) recommends treatment when TDS concentrations exceed 500 mg/L, or 500 parts per million (ppm). The TDS concentration is considered a Secondary Drinking Water Standard, which means that it is not a health hazard. However water with a high TDS concentration may indicate elevated levels of ions that do pose a health concern, such as aluminum, arsenic, copper, lead, nitrate and others. These results are also in agreement as reported by Farooq *et al*., (2008). The value of TDS was lowest at *Station # 4* with

office machine trial version

values ranging from 332 to 354 mg/L with mean value of 339 mg/L while maximum value was obtained at *Station # 6* with mean value of 368 mg/L.

Conductivity values were found varying in between 683 to 749 µS/cm at *Station # 4* and *6*. All the parameters are within WHO standards of drinking water quality. As the concentration of dissolved salts (usually salts of sodium, calcium and magnesium, bicarbonate, chloride, and sulfate) increases in water, electrical conductivity increases (Kelin *et al*., 2005).

The microbiological quality of drinking water can be significantly affected by turbidity. Highest value of turbidity was obtained at *Station # 2* with mean value of 1.27 NTU while lowest value was observed at over head tank at I-8 with mean value of 0.34 (Figure 1). Similar results were also reported by National Water Quality Program, (PCRWR, 2005). On the other hand, Heterotrophic plate count (HPC) increases with parallel increase in turbidity as reported earlier by Snead, 1980. Similarly, Chlorine (as hypochlorous acid) reacts readily with organic matter containing unsaturated bonds, phenolic groups and nitrogen groups, giving rise to taste- and odor-producing compounds and trihalomethanes (THMs). Hence, waters with high turbidity from organic sources may give rise to a substantial chlorine demand and so is unavailable to kill pathogens (Crump, 2004). This could result in reductions in the free chlorine residual in distribution systems as protection against possible recontamination.

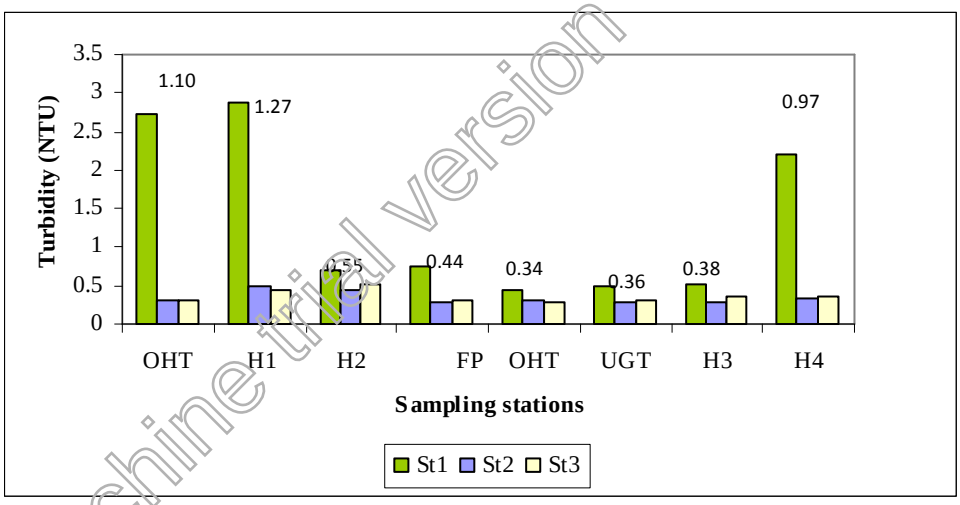


Figure 1: Values of Turbidity obtained at different sampling stations of sector I-

The value of total residual chlorine varied from 0.05 mg/L at *Station # 3* to 0.13 at *Station # 1*. Free chlorine residual was also detected in the system with average values varying from 0.02 mg/l at *Station # 3* to 0.09 at *Station # 1*(Figure 2). Minimum level of monochloramine available at consumer end was detected at *Station # 3* with mean value of 0.01mg/L and maximum level was obtained at *Station # 6* with mean of 0.08 mg/L. Values of dichloramines ranged from 0.17 to 0.06 mg/L at *Station # 3* and *6*.

pdfMachine trial version

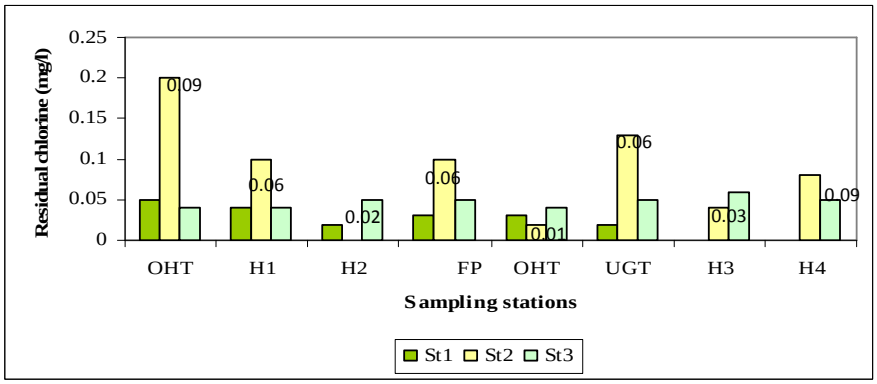


Figure 2: Values of Residual chlorine obtained at different sampling stations of Sector I-8.

Most probable number (MPN) test was conducted to determine the presence of *total coliform* and *fecal coliform* in drinking water samples. Microbial analysis of drinking water samples revealed that fecal contamination was detected at *Station # 3* with MPN /100mL of 16.1, at *Station # 5*and *7* MPN/100 mL was 6.9 and at *Station # 8* MPN/100ml was 5.1. While at the rest of the stations MPN/100 ml was <1.1 indicating that there was no presence of *fecal coliform* (Figure 3).

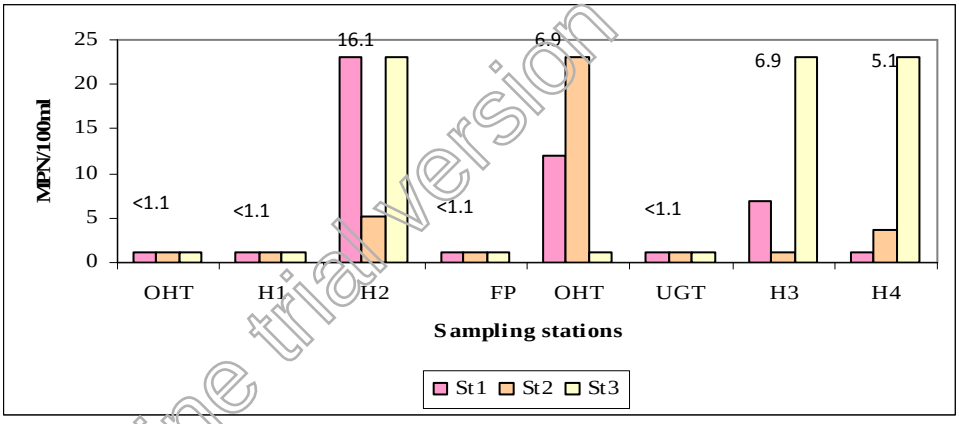


Figure 3: Values of *fecal coliform* count obtained at different sampling stations of sector I-8

The standard plate count (SPC) is considered by some scientists to be a better indicator of potable water quality than the coliform index (Geldreich, 1972).The viable count was measured by the SPC. The maximum SPC counts were observed at *Station # 3* with values ranging from 81 to 370 CU/mL with average value of 267 CFU/ml. At the rest of the stations SPC counts were below countable range. These results are in line with the study conducted by Le Chevallier *et al*., (1980). So from the analysis it revealed that water sample from *Station # 3* was highly contaminated, this may be due to cross contamination of water supply line with sewage water and unhygienic condition of under ground storage tank (Figure 4). The cumulative values of all the parameters are given in Table-1.

pdfMachine trial version

Table 1: Mean value of Microbial and Chemical Analysis of Water Samples Collected from Residential area of I-8 during July & August 08*

Water Parameters	Station Numbers							
	1	2	3	4	5	6	7	8
Station Name	**UGT**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
Temp in ºC	25.6	26.2	26.7	25.8	26.13	5.8	25.76	20.06
pH	7.10	7.26	7.6	7.62	7.41	7.24	7.56	7.21
TDS (mg/l)	354	353	343.3	339	362.3	368	363	357
Conductivity(µS/cm)	714	718	689.6	683.6	737	749	739	726
Turbidity (NTU)	1.10	1.27	0.55	0.45	0.34	0.36	0.38	0.97
Total Chlorine (ppm)	0.13	0.093	0.05	0.27	0.06	0.12	0.12	0.06
Free chlorine	0.09	0.06	0.023	0.06	0.03	0.06	0.033	0.043
Monochloramine	0.04	0.033	0.016	0.02	0.023	0.05	0.07	0.06
Dichloramines	0.03	0.006	0.05	0.05	0.04	0.06	0.046	0.053
Total Coliform (MPN index/100ml)	<1.1	<1.1	12.0	<1.1	9.2	<1.1	6.9	5.1
Fecal Coliform (MPN index/100ml)	<1.1	<1.1	12.0	<1.1	9.2	<1.1	6.9	5.1
Range 95% Probability	0-3.0	0-3.0	4.3-27.1	0-3.0	3.1-21.1	0-3.0	2.1-16.8	1.3-13.4
CFU /ml	5	12	267	2	36.3	0	3	2

Demachine trial version

NTU=Nephlometric turbidity units, **CFU**=Colony Forming Units, **UGT=**Underground tank, **H (1, 2, 3, 4, 5, 6,7)** = Consumer houses

* Based on mean of three replicates (Dated: 20/08/08, 02/09/08, 11/09/08)

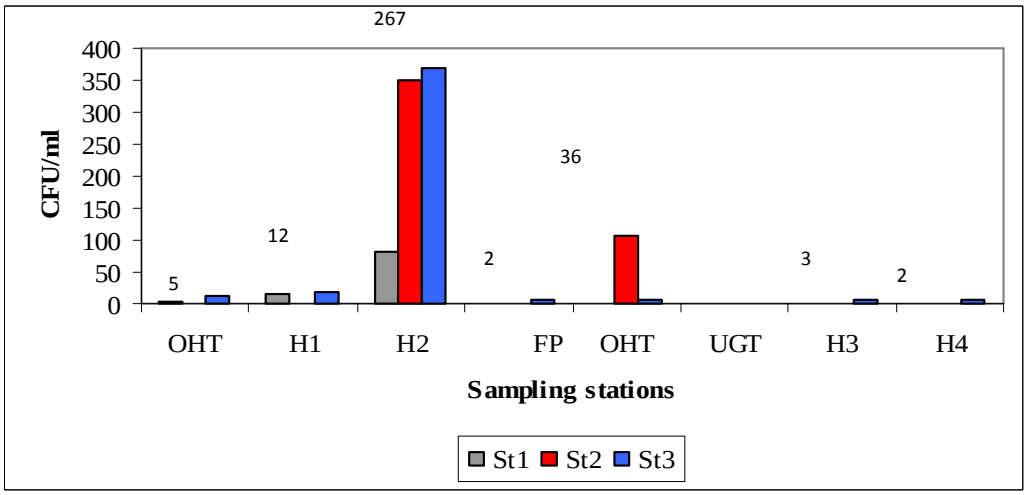


Figure 4: Values of SPC counts obtained at different sampling stations of sector I-8

The water samples collected were also analyzed for TOC. The analysis results were alarming as high amount of TOC was observed at all of the sampling stations which were above standards of treated drinking water i.e., above 2 mg/L. The values were found to be ranging from 7.67 to 22.57 mg/L. The main water supply had a TOC value of 11.22 mg/l. These are in line with the study conducted by Wallace *et al*., (2002) (Figure 5). According to their study, TOC monitoring is required monthly for one source water and one treated water sample. If the TOC levels of the source water average less than 2mg/L^{-1} C for two consecutive years, or the treated water average is less than 1mgL^{-1} C

pdfMachine trial version

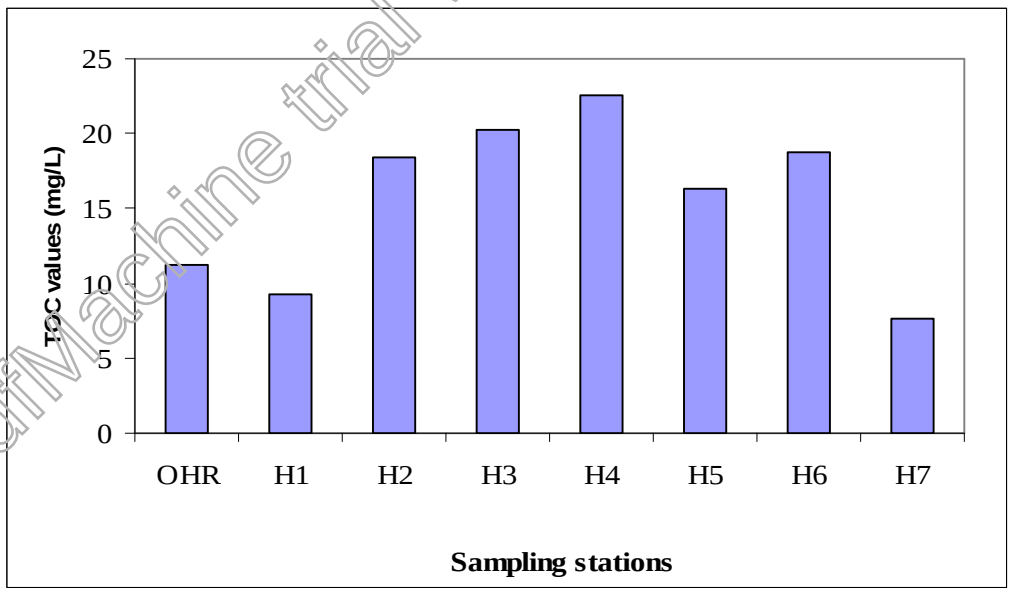


Figure 5: Average values of TOC obtained at different sampling stations of sector I-8

for 1 year, then a public water system would qualify for reduced monitoring to one pair of samples per quarter.

4. Conclusions

1. The analysis revealed that the water is safe for drinking with value of pH 7.10, TDS of 354 mg/l, conductivity of about 714 µS/cm and turbidity of 1.10 NTU in water from overhead tank.

2. The value of total chlorine was estimated to be 0.13 mg/l; free chlorine was 0.09 mg/l, monochloramine of 0.04 mg/l and dichloramines of 0.03 mg/l in the over head tank.

3. All the chemical parameters were within WHO standards of drinking water quality. But turbidity was highest with mean value of 1.27 NTU at *Station # 2.*

4. The value of total chlorine varied from 0.05 mg/l at *Station # 3* to 0.13 at *Station # 1.* Free chlorine residual was also detected in the system with average values varying from 0.02 mg/l at *Station # 3* to 0.09 at *Station # 1.*

5. Microbial analysis of drinking water samples revealed that fecal contamination was detected at *Station # 3* with MPN /100ml of 16.1, at *Station # 5*and *7* MPN/100 ml was 6.9 and at *Station # 8* MPN/100ml was 5.1

6. In light of the increasing concerns over pathogenic contamination in distribution systems and the documented deficiencies in the efficacy of the disinfectant barrier, an additional monitoring is required to protect public health and provide early warning of accidental pathogenic contamination events. While at the rest of the stations MPN/100 ml was <1.1 indicating that there was no presence of *fecal coliform*

7. The maximum SPC counts were observed at *Station # 3* with values ranging from 81 to 370 CU/ml with average value of 267 CFU/ml. At the rest of the stations SPC counts were below countable range. So from the analysis it revealed that water sample from *Station # 3* was highly contaminated, this may be due to cross contamination of water supply line with sewage water and unhygienic condition of underground storage tank.

8. The analysis results were alarming as high amount of TOC was observed at all of the sampling stations which were above standards of treated drinking water i.e. above 2 mg/l. The values were found to be ranging from 7.67 to 22.57 mg/l. The main water supply had a TOC value of 11.22 mg/L.

5. Recommendations

1. It is recommended that there should be regular monitoring of physical, chemical and biological quality of drinking water being treated at any treatment facility in order to ensure good water quality provision to the community.

pdfMachine trial version

2. A regular monitoring of residual chlorine concentration and microbiological contamination of water in the distribution system is recommended to ensure that after travelling a long distance the water supplied to the community, considerable amount of residual chlorine should still be present to combat the microbes which accidentally enter the distribution network.

3. Optimization of chlorine dosage according to the requirement because if the dosing rate of chlorine is too low, there may be insufficient residual chlorine at the end of the distribution system, resulting in bacterial regrowth. On the other hand, the addition too much chlorine can lead to customer complaints about taste and odor, corrosion of the pipe network.

4. It is recommended that the departments responsible for water supply in urban areas in particular should replace age-old leaking pipes in their water supply systems because they are a major cause of bacterial contamination even in treated water in the distribution.

6. Acknowledgement: We gratefully acknowledge the financial support of Higher Education Commission (No. 20-874/HEC/R&D/07/379), Pakistan to carry out this research and the support of staff from Khanpur Filtration Plant, Islamabad, Pakistan.

7. References

APHA. (2005). American Public Health Association, Standard Methods for the Examination of Water and Waste water, Washington.

Bailey, I. W. & Thompson, P. (1995). Monitoring water quality after disinfection. Wat. Suppl. 13(2): 35–48.

Ballmer, B., Korczak, B. M., Kuhnert, P., Slickers, P., Ehricht, R and Ha¨chler1, H. (2007). Fast DNA Serotyping of *Escherichia coli* by Use of an Oligonucleotide Microarray. journal of clinical microbiology. 45 (2): 370–379.

Crump, J. A., Okoth, G. O., Slutsker, L., Ogaja, D. O., Keswick, B. H. & Luby, S. P.(2004). Effect of point-of-use disinfection, flocculation and combined flocculation-disinfection on drinking water quality in western Kenya. Journal of Applied Microbiology. 97(1): 225–231.

Donnermair, M. M and Blatchley, E. R. (2003). Disinfection efficacy of organic chloramines. Water Research. 37: 1557–1570.

EPD (2001). Water quality: Ambient water quality guidelines for organic Carbon**.** Environment Management Act, 1981. Environment Protection Division, Ministry of Environment.

Farooq, S., Hashmi, I., Qazi, I. A., Qaiser, S. & Rasheed, S. (2008). Monitoring of coliform and chlorine residual in water distribution network of Rawalpindi. Environmental Monitoring and Assessment. 140(1-3): 339-347.

pdfmachine trial version

Geldreich, E. (1996). Microbiological Quality of Water Supply in Distribution Systems. CRC Lewis Publishers, Boca Raton, Florida.

Geldreich, E. E., Nash, H. D., Reasoner, D. J. & Taylor, R. H. (1972). The necessity of controlling bacterial populations in potable waters; community water supply. J. Am. Water Works Assoc. 64: 596-602.

Helbling, D. E and VanBriesen, J. M. (2008). Continuous monitoring of residual chlorine concentrations in response to controlled microbial intrusions in a laboratory-scale distribution system. J. Water Research 42: 3162 – 3172.

Kelin, H., Yuang, H. F., Hong, L., & Robert, W. E. (2005). Spatial variability of shallow ground water level, electrical conductivity and nitrate concentration and risk assessment of nitrate contamination in North China plain. Environment International. 31: 896–903.

Kitazawa, H. (2006). Keeping residual chlorine and decreasing unpleasant odor caused by disinfection of tap water. Water Supp. 6(2):193-199.

LeChevallier, M. W., Welch, N. J. & Smith, D. B. (1996). Full-scale studies of factors related to coliform regrowth in drinking water. Appl. Environ. Microbiol. 62 (7): 2201–2211.

LeChevallier, M. W., Schulz, W and Lee, R. G. (1991). Bacterial nutrients in drinking water. Appl. Environ. Microbiol. 57(3): 857-862.

Le Chevallier, M. W., Cawthan, C. D and Lee, R. G (1988). Factors promoting survival of bacteria in chlorinated water supplies. Applied and Environmental Microbiology. 54 (3): 649-654.

LeChevallier, M. W., Seidler, R. J. & Evans T. M. (1980). Enumeration and characterization of standard plate count bacteria in chlorinated and raw water supplies. Applied and Environmental Microbiology. 40(5): 922-930.

Liang, J., Dziuban, E., Craun, G., Hill, V., Moore, M., Gelting, R., Calderon, R., Beach, M., Roy, S. (2006). Surveillance for waterborne- disease and outbreaks associated with drinking water and water not intended for drinking—United States, 2003–2004. Morbidity Mortality Weekly Rep. 55 (SS-12): 31–58.

Licence, K., Oates, K.R., Synge, B.A and Reid, T.M.S. (2001). An outbreak of E. coli O157 infection with evidence of spread from animals to man through contamination of a private water supply. Epidemiol. Infect. 126: 135–138.

Lienyao, L., Chungsying, L., & Shyang-Lai, K. (2004). Spatial diversity of chlorine residual in a drinking water distribution system. Journal of Environmental Engineering, 130, 1263–1268.

Min, J and Baeumner, A., J. (2002). Highly sensitive and specific detection of viable *Escherichia coli* in drinking water. Anal Biochem. 303(2): 186.

pdfMachine trial version

PCRWR. (2005). Pakistan Council of Research and Water Resources, National Water Quality Monitoring Programme, Report 2004, Islamabad.

Ram, S., Vajpayee, P., Singh, R. L. and Shanker, R. (2009). Surface water of a perennial river exhibits multi-antimicrobial resistant shiga toxin and enterotoxin producing Escherichia coli. Ecotoxicology and Environmental Safety. 72 (2): 490-495.

Schets, F. M., During, M., Italiaander, R., Heijnen, L., Rutjes, S. A., Zwaluw, W. K. V and Husman A. M. R. (2005). *Escherichia coli* O157:H7 in drinking water from private water supplies in the Netherlands. Water Research. 39: 4485–4493.

Schoenen, D. (2002). Role of disinfection in suppressing the spread of pathogens with drinking water: possibilities and limitations. Water Research 36 (2002) 3874–3888.

Shang, C and Blatchey, E. R. (2001). Chlorination of pure bacterial culture in aqueous solution at. Res. 35 (1): 244-254.
Snead, M. C., Olivieri, V. P., Kruse, C.W. and Kawata, K. (1980). Benefits of maintaining a chlorine residual in water supply systems. EPA-600/2-80-010. U.S. Environmental Protection Agency, Washington, DC.

UNDP. (2003). Pakistan National Human Development Report, “Water Crisis”, Karachi, p. 7 &103.

US-EPA (1999). EPA Office of Water: Alternative Disinfectants and Oxidants Guidance Manual. (EPA 815-R-99-014). Washington, D.C.

US-EPA. (1978). Methods for the chemical analysis of water and wastes. US-EPA-625/6-74-003. Washington DC: Office of Technology Transfer.

Wallace, B., Purcell, M and Furlong, J. (2002). Total organic carbon analysis as a precursor to disinfection by products in potable water: Oxidation technique considerations. J. Environ. Monit. 4: 35–42.

WB-CWRAS. (2005). The World Bank ‘Pakistan country water resources assistance strategy water economy: Running dry’. Washington DC: WB-CWRAS.

pdfMachine trial version

RAINWATER HARVESTING POTENTIALS FOR RAWALPINDI AND ISLAMABAD

By

Muhammad Ali and Zahiruddin Khan[1]

Abstract

In most urban areas, population is increasing rapidly and the issue of supplying adequate water to meet societal needs and to ensure equity in access to water is one of the most urgent and significant challenges faced by decision-makers. Among the various alternative technologies to augment freshwater resources, rainwater harvesting and utilisation is a decentralised, environmentally sound solution, which can avoid many environmental problems often caused in conventional large-scale projects using centralised approaches. Collecting water from roofs via traditional guttering and through down pipes to a storage tank. It can then be used for a variety of uses such as watering gardens, reduce urban flooding and reduce erosion. In Rawalpindi and Islamabad main source of the water supply is surface water. Groundwater table is rapidly decreasing. On the other hand only in urban area (545.40 KM^2) of the cities approximately 610 million cubic meters of rainfall occur annually. This sufficient amount of water can be utilized for variety of the purposes specially for watering the gardens, neighborhood parks and city parks. Moreover it can reduce the dependency on the groundwater and can be a potential source of drinking water.

1. Introduction

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams and cistern. The techniques usually found in Asia and Africa arise from practices employed by ancient civilizations within these regions and still serve as a major source of drinking water supply in rural areas.

Rainwater harvesting is also effective in reducing storm water runoff pollution. When rainfalls, it is clean, but it immediately picks up pollutants from rooftops and pavement. This pollution is carried into storm drains and then into streams. Collecting storm water from rooftops and directing it to storage tanks so it can later be used for irrigation or flushing decreases the volume and rate of runoff.

The installation of rainwater harvesting systems (i.e., the use of rainwater collected on-site) has been increasing throughout the US and Canada. Different advantages of rainwater harvesting are listed below.

pdfMachine trial version

1. Institute of Environmental Science and Engineering, National University of Science and Technology - Rawalpindi

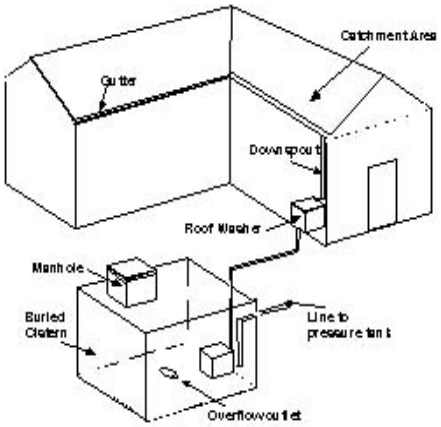


Figure 1. Basic rainwater harvesting system

i. Provide a source of free water—the only costs would be for storage,
ii. Treatment and use;
iii. Provide water if there is no other source of water;
iv. Augment or replace limited quantities of groundwater;
v. Provide good-quality water if groundwater quality is unacceptable;
vi. Provide water if tap charges are too high for water supply connection;
vii. Reduce storm water runoff;
viii. Reduce non-point source pollution;
ix. Reduce erosion in urban environments;
x. Provide water that is naturally soft (no need for water softeners);
xi. Provide water that is pH neutral/slightly acidic;
xii. Provide water that is sodium-free, important for those on low-sodium diets;
xiii. Provide good quality water for landscape irrigation;
xiv. Provide water for non-potable indoor uses;
xv. Provide safe water for human consumption, after appropriate treatment;
xvi. Help utilities in reducing peak demands in the summer;
xvii. Help utilities in delaying the expansion of water treatment plants;
xviii. Provide water for cooling and air-conditioning plants;
xix. Reduce the demands on groundwater;
xx. Provide water for fire protection; and
xxi. Save money for the consumer in utility bills.

There are several component of the rainwater harvesting system.

These components are rainwater catchments, conveyance, purification, and storage and distribution network. Component of the rainwater harvesting system are shown in the figure -1.

2. Statement of the Problem

As the world's population continues to grow, now at a rate of about 10,000 per hour, our same finite water resources are going to have to go farther and be treated wisely. In order to meet our future water needs, solutions are needed that are both economical and environmentally friendly.

In case of Rawalpindi and Islamabad, groundwater level is very much low. As groundwater is the main source of potable water other main source of potable water in these cities are Rawal Dam and Khanpur Dam. In Islamabad the drop in the water table has been 50 feet from 1986 to 2001.

pdfMachine trial version

On the other hand, adequate rainfall occurs in these cities, which is not being capitalized in any way. In these cities, rainwater harvesting can be a potential source of potable water supply and other uses. Moreover, this sufficient amount of precipitation falls and many contaminates into Nala-Lai and Sawan River subsequently and polluting the surface water rapidly. There is an emergent need to carry out study to identify the potentials of rainwater for the beneficial uses of the cities.

Groundwater is becoming scarcer in large urban areas due to reduced water infiltration. The decrease of groundwater recharge in the cities is directly proportional to the increase in the pavement and roof area. In addition, high population density has brought about high groundwater consumption. Recognising, the need to alter the drainage system and to harvest the rainwater.

3. Objectives

The objectives of the study are as followings

1. Spot the sustainable potential uses of rainwater harvesting for Rawalpindi and Islamabad.
2. Quantify the total volume of the precipitation by using GIS, occurred in the last few years in these cities.
3. Suggest the recommendations for the potential uses of the rainwater.

4. Scope

Scope of the study may be divided into two broader parts. First is geographical scope, and geographical scope of the study is municipal limits of the cities. Second is theoretical scope, and theoretical scope of the study is to figure out the potentials of rainwater harvesting for the cities.

5. Methodology

Following steps was followed to carried out this study

Objective	Method Employed	Target Achieved
Download satellite images of the cites and mosaic them to form a single image	***Google Earth Professional*** for image downloading and ***Erdas Imagine 8.7*** for Mosaicing of images.	Map of the cities
Geo-reference the image	***Erdas Imagine 8.7*** ***Arc GIS 9***	Scaled Map of the cities
Plot Precipitation Data	Coordinates of the Rain gage stations was obtained then plotted on scaled map of the cities by using ***Arc GIS 9.*** Isohyets were drawn on the map.	Isohyets Map of the cities
Quantify the Volume of Precipitation	Municipal limits of the cities was earmarked and total area would be found by using ***Arc GIS 9.***	Volume of Precipitation
Digital Elevation Model (DEM) of the cities	DEMs was obtained from internet and simple map of the city was converted into topographical map by using ***Arc GIS 9.***	Topographical map of the city
Treatment of rainwater and other potential uses of rainwater	Treatment train of the rainwater would be designed and other potential uses rainwater would be identified.	Harvesting of rainwater

pdfMachine trial version

In short span of time it was not possible to conduct entire study. But the aim of this practice is to familiar student with this technique and about the methodology, how would go for it. Although, municipal boundaries of the cities and precipitation data of some stations were assumed in order to complete this task. But still it was good practice to make student understand about this technology. Methodology is briefly described in a flow chart below. (Figure 2)

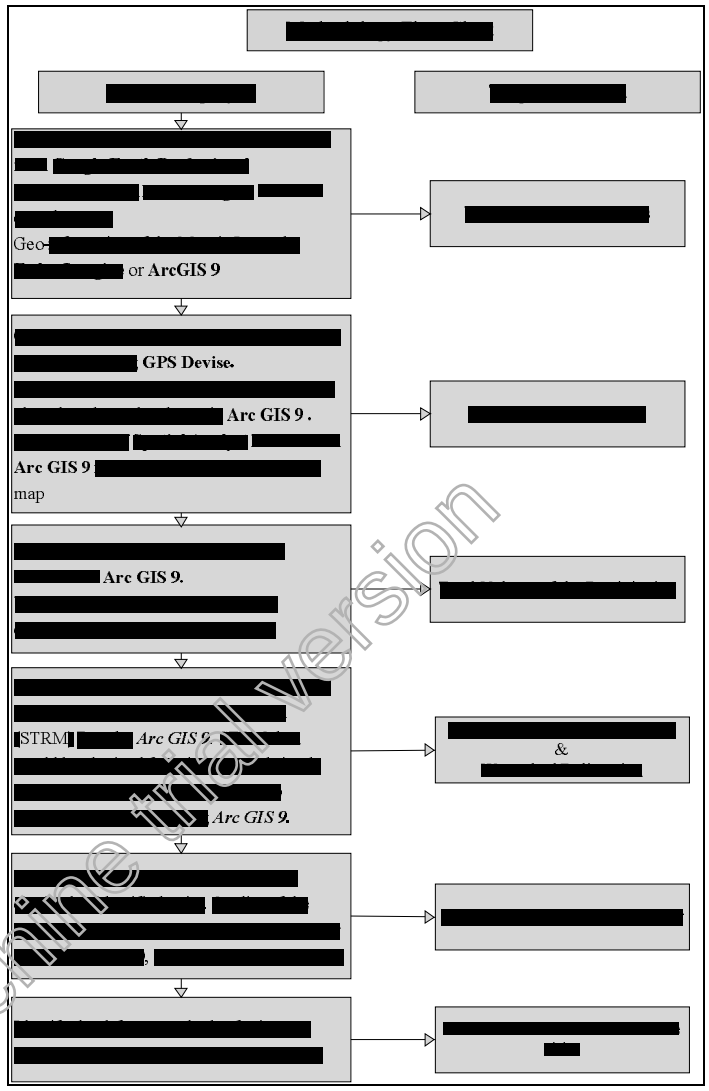


Figure 2: Flow Chart of the Methodology

pdfMachine trial version

6. Results & Discussions

Precipitation data from the Meteorological department was obtained unfortunately data for all the stations were not available because those gauge stations were not classified. Anyhow seven rain gauge stations were plotted on the map of GIS, location and annual average precipitation are shown in the table below.

Table 1: Location and Annual Average Precipitation of Rain gauge

Name of Rain gauge	Annual Average Precipitation (mm)	Location of Rain gauge	
		Easting	Northing
G - 11/1	1200	72°59'43.99"	33°39'20.76"
Arid University	979	73°5'8.92"	33°38'48.11"
Airport	1247	73°6'2.94"	33°36'38.70"
Meteorological Deptt.	1180	73°3'57.16"	33°40'53.08"
OPQS Qasim	900	73°1'59.41"	33°33'36.06"
B. Town	1000	73°10'0.41"	33°32'11.81"
Park	1050	73°10'28.71"	33°44'18.07"

It is estimated that the total urban area of Rawalpindi and Islamabad is about 545.20 KM^2. Mean annual average precipitation in these cities about 1172 mm/year.

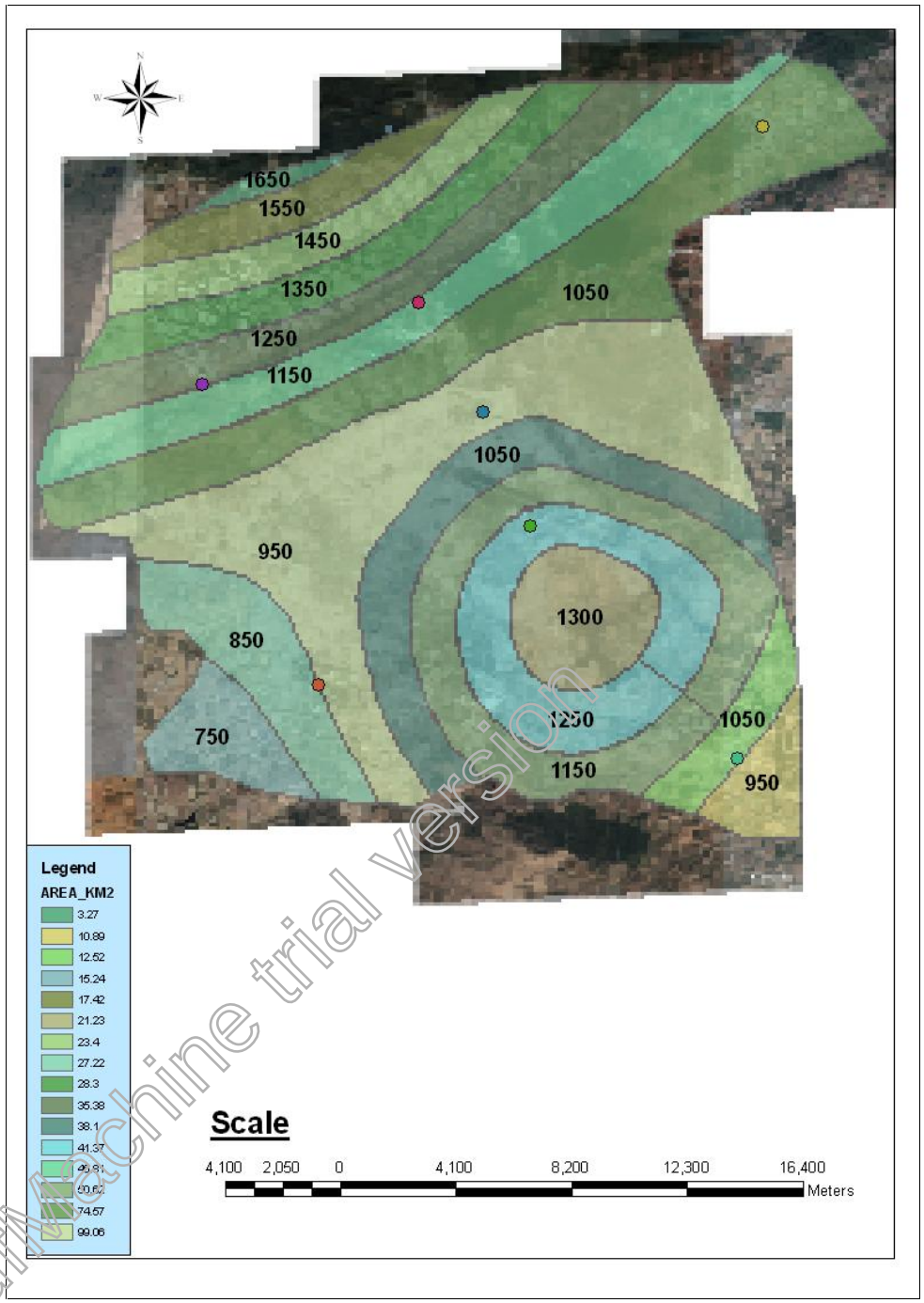
Table 2: Mean Annual Volume of the Rainfall

Sr. No.	Area	Annual Average Precipitation (mm)	Volume of Precipitation (Million M^3)
1	3.27	1650	5.40
2	21.23	1300	27.60
3	41.37	1250	51.71
4	10.89	950	10.35
5	12.52	1050	13.15
6	17.42	1550	27.00
7	23.40	1450	33.93
8	28.30	1350	38.21
9	35.38	1250	44.23
10	46.81	1150	53.83
11	74.57	1050	78.30
12	15.24	750	11.43
13	27.22	850	23.14
14	38.10	1050	40.01
15	99.06	950	94.11
16	50.62	1150	58.21
Total	**545.40**	**1172[1]**	**610.58**

[1] Mean Annual Average Precipitation

pdfMachine trial version

From the calculation it is depicted that the volume of the precipitation for the area of Rawalpindi and Islamabad is approximately 610 million cubic meters annually. Figure – 3 showing the isohyets of the cities.



pdfMachine trial version

Figure 3: Isohyetal Map of Rawalpindi and Islamabad

7. Practices of Rainwater Harvesting

Some of the examples of rainwater harvesting are mentioned below.

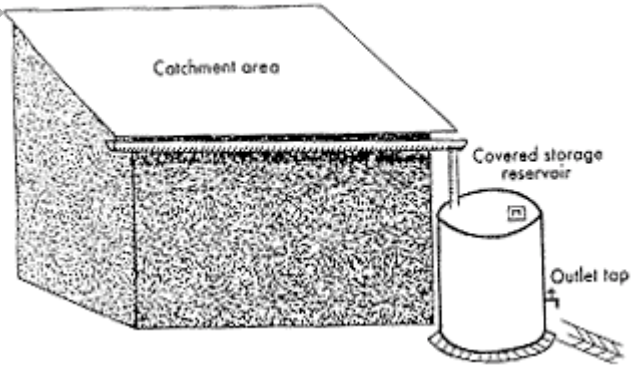
1. Light roofing is placed on the roofs to act as catchments. Collected roof water is kept in separate cisterns on the roofs for non-potable uses.
2. The water is used primarily for non-potable functions such fire-fighting drills and toilet flushing. Such collected and treated water accounts for 28 to 33% of the total water used, resulting in savings of approximately S$ 390,000 per annum in Singapur.
3. In Tokyo, rainwater harvesting and utilization is promoted to mitigate water shortages, control floods, and secure water for emergencies.
4. Storing rainwater from rooftop run-off in jars is an appropriate and inexpensive means of obtaining high quality drinking water in Thailand.
5. Indonesian government introduced a regulation requiring that all buildings have an infiltration well. The water deficit of 53% by the year of 2000 would be reduced to 37%, which translates into a net savings of 16% through conservation.
6. In Bangladesh, rainwater collection is seen as a viable alternative for providing safe drinking water in arsenic affected areas. Since 1997, about 1000 rainwater harvesting systems have been installed in the country, primarily in rural areas.

Similarly, there are many more examples around the world. Many countries are using rainwater sustainable.

Rainwater harvesting systems can provide water at or near the point where water is needed or used. The systems can be both owner and utility operated and managed. Rainwater collected using existing structures (i.e., rooftops, parking lots, playgrounds, parks, ponds, flood plains, etc.), has few negative environmental impacts compared to other technologies for water resources development. Rainwater is relatively clean and the quality is usually acceptable for many purposes with little or even no treatment. The physical and chemical properties of rainwater are usually superior to sources of groundwater that may have been subjected to contamination.

8. Types of Rainwater Harvesting Systems

Typically, a rainwater harvesting system consists of three basic elements: the collection system, the conveyance system, and the storage system. Collection systems can vary



pdfMachine trial version

Figure 4: Example of a roof catchment system.

from simple types within a household to bigger systems where a large catchment areas contributes to an impounding reservoir from which water is either gravitated or pumped to water treatment plants. The categorisation of rainwater harvesting systems depends on factors like the size and nature of the catchment areas and whether the systems are in urban or rural settings. Some of the systems are described below.

8.1 Simple roof water collection systems

While the collection of rainwater by a single household may not be significant, the impact of thousands or even millions of household rainwater storage tanks can potentially be enormous.

The main components in a simple roof water collection system are the cistern itself, the piping that leads to the cistern and the appurtenances within the cistern. The materials and the degree of sophistication of the whole system largely depend on the initial capital



Figure 5: At Kokugikan sumo wrestling arena in Tokyo, Japan, rainwater collected from the arena's 8,400 square meter rooftop is used for non-potable purpose.

navacme final version

investment. Some cost effective systems involve cisterns made with ferro-cement, etc. In some cases, the harvested rainwater may be filtered. In other cases, the rainwater may be disinfected

8.2 Larger systems for educational institutions, stadiums, airports, and other facilities

When the systems are larger, the overall system can become a bit more complicated, for example rainwater collection from the roofs and grounds of institutions, storage in underground reservoirs, treatment and then use for non-potable applications.

8.3 *Roof water collection systems for high-rise buildings in urbanised areas*

In high-rise buildings, roofs can be designed for catchment purposes and the collected roof water can be kept in separate cisterns on the roofs for non-potable uses.

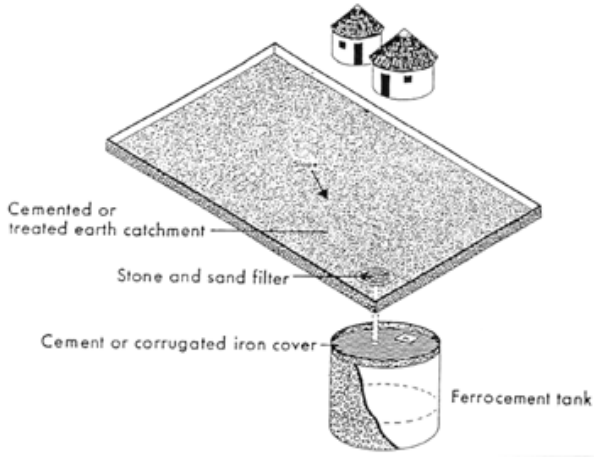


Figure 6: Example of a ground catchment system.

8.4 Land surface catchments

Rainwater harvesting using ground or land surface catchment areas can be a simple way of collecting rainwater. Compared to rooftop catchment techniques, ground catchment techniques provide more opportunity for collecting water from a larger surface area. By retaining the flows (including flood flows) of small creeks and streams in small storage reservoirs (on surface or underground) created by low cost (e.g., earthen) dams, this technology can meet water demands during dry periods. There is a possibility of high rates of water loss due to infiltration into the ground, and because of the often marginal quality of the water collected, this technique is mainly suitable for storing water for agricultural purposes.

8.5 Collection of storm water in urbanized catchments

The surface runoff collected in storm water ponds/reservoirs from urban areas is subject to a wide variety of contaminants. Keeping these catchments clean is of primary importance, and hence the cost of water pollution control can be considerable.

9. Conclusion

Rainwater can meet many needs and many designs can be used to capture and store and reuse rainwater. All rainwater harvesting systems have a similar set of functions and components though they vary in complexity and efficiency. A simple process focused on understanding use needs, rainfall patterns and resources can contribute to an appropriate system. Annually, there is 610 million cubic meters of rainfall occurring in the urban area of the Rawalpindi and Islamabad. If 50% of the total rainfall volume would be used for beneficial purposes than our ground and surface water resources can preserved. Water resources are getting depleted day by day it is required to preserve them by using wisely rainwater.

PDFMachine trial version

References

1. Butler, K; Roy, A; and Rosato, J; (2007). *"Rain catchments and adaptive building reuse: The Historic Seaholm Power Plant".* The University of Texas. Austin
2. Colin, R; and J, Peter (2007). "*Urban rainwater harvesting analysis of a decentralized approval for meeting water demand in urban cities. An opportunity for the United States of America".* Research Fellow in Integrated Water Cycle Management. University of Newcastle. Australia.
3. Schultz, Jack; and Schultz, Bill; (2007). "*Design And Operation Of A Residential Rainwater System For Potable Water And Fire Protection Perspectives of Designer, Builder And Owner"* American Rainwater Catchment System Association Conference.
4. South Asia Environment and Social Development Unit (October, 2006). *"Pakistan Strategic Country Environmental Assessment."* The World Bank.
5. Texas rainwater harvesting evaluation committee (November 2006). *"Rainwater harvesting potential and guidelines for Texas"*. Texas Water Development Board. Austin: Texas
6. http://www.google.com.pk/search?hl=en&q=define%3A+rainwater+harvesting&btnG=Google+Search&meta=
7. http://www.google.com.pk/search?hl=en&q=define%3A+rain+harvesting&btnG=Search&meta=
8. http://www.portlandonline.com/osd/index.cfm?print=1&c=ecbbd&a=bbehfa
9. http://www.therainwell.com/RainWaterUses.html
10. http://www.oksustainability.org/ppt/steven_shepelwich2005_files/frame.htm
11. http://www.montana.edu/wwwpb/pubs/mt9707.html
12. http://www.unep.or.jp/ietc/Publications/Urban/UrbanEnv-2/2.asp

pdfMachine trial version

SUSTAINING IRRIGATED AGRICULTURE IN THE 21ST CENTURY : OPTIONS FOR PAKISTAN

By

Asad Sarwar Qureshi and Khalid Mohtadullah*

ABSTRACT

Pakistan is also one of those countries that could face severe food shortages in the 21st century, which are intimately linked to water scarcity. It is projected that shortfall of water requirements would be about 32 percent which will result in 70 million tones of food shortages by the year 2025. It is also predicted that after an initial period of high flows in the form of storms due to faster glacial melt there will be a terrifying decrease in inflows of anywhere between 30-40 percent into the Indus river system. Recent estimates suggest that climate change and siltation of main reservoirs will reduce the surface water storage capacity by 30% by 2025. This reduction in surface supplies and consequent decreases in groundwater abstraction will have serious effect on irrigated agriculture, which produces more than 90 percent of the total agricultural production in Pakistan. This situation has threatened the food security of 170 million people living in Pakistan. It is, therefore, imperative that Pakistan should invest soon in increasing storage capacity, improving water use efficiency, managing surface water and groundwater resources in a sustainable way to avoid problems of soil salinization and water-logging. Current low productivity in comparison to what has been achieved in other countries under nearly similar conditions points to the enormous potential that exists. Of course, building capacity of individuals and organizations and strengthening institutions are key elements for achieving these targets.

BACKGROUND

Indus Basin Irrigation System (IBIS)

The Indus Basin Irrigation System (IBIS) commands a gross irrigable area of 16.85 million hectares (Mha), of which 14 Mha is culturable command area (CCA) to which water is allocated. The perennial canal supply is available to 8.6 Mha while the remaining area is entitled to irrigation supplies only during the summer (Kharif) season. The Indus River and its tributaries, on an average, bring 175 billion cubic meters (BCM) of water annually. This includes 165 BCM from the three Western Rivers (Indus, Chenab and Jehlum) and 10 BCM from Eastern Rivers (Ravi, Beas and Sutlej). Most of this, about 128 BCM, is diverted for irrigation, 35 BCM flows to the sea and about 12 BCM is wasted as the system losses (Zuberi, 1997).

The average safe groundwater yield is estimated to be about 63 BCM, whereas the extraction for agriculture, domestic and industrial sectors is of the order of about 52 BCM. Thus the remaining groundwater potential is about 11 BCM (PWP, 2001). While these figures may suggest some potential for further exploitation of groundwater, other evidences such as increasing salinity in the groundwater due to redistribution of salts in

Machine trial version

* Water Resources Management Specialist and Director, IWMI-Pakistan Office, 12 KM, Thokar Niaz Beg, Lahore.

the aquifer and declining groundwater levels confirm that potential for further groundwater exploitation is very limited.

Increasing Gap in Supply and Demand

The water requirements for irrigation in the Indus Basin are estimated at 250 BCM in 2025 against the availability of 185 BCM. Even by exploiting the full groundwater resources, the water availability will not be more than 190 BCM. Considering the reduction in present storage capacities due to siltation and non-availability of additional storage facilities, the shortfall of water requirements would be about 32 percent by the year 2025 (ADB, 2002). In the "business as usual" scenario, shortfall of water will result in serious food shortages in the years to come and will severely hurt the national economy and livelihood of millions. Estimated requirements of the agricultural commodities for the project population in 2025 are given in Table 1.

Table 1: Projected food requirements and productions for the year 2025 (Million Tons).

Crops	Requirement	Production	Shortfall
Food-Grains	50	31.5	18.5
Sugarcane	82	46.4	35.4
Cotton (lint)	3.5	2.7	0.8
Pulses	1.9	1.4	0.5
Oilseed	3.3	1.5	1.8
Vegetables	14.3	9.0	5.3
Fruits	16.1	9.0	7.1
Total	171	102.8	69.4

Source: ADB water Sector strategy for Pakistan, 2002.

Low System Efficiency and Crop Productivity

Pakistan has a large stock of water infrastructure with an estimated replacement cost of about US$ 60 billion (World Bank, 2006). Much of this infrastructure is very old and operating beyond their designed life. The services provided by this infrastructure are very crucial for sustainable irrigated agriculture and the national well being. However, these services can only be available if the structures are well maintained and, when their useful life is over, replaced.

The overall irrigation efficiency in the Indus basin is about 30% (Bhutta and Smedema, 2007). In addition to water shortage, lack of inputs and poor irrigation practices, soil salinization are the other major factors for low crop yields. The average yields in Pakistan are low for wheat and rice, being 2276 kg ha^{-1} and 1756 kg ha^{-1}, respectively. There is a great variability in crop yields with some farmers achieving yields of 3874 kg ha^{-1} for wheat and 3545 kg ha^{-1} for rice (Qureshi, 2004).

Inequity in Water Distribution

Conceptually the major task for water managers in the Indus Basin is to provide water in a predictable and timely manner to those who need it and have a right to it. This task is done less and less satisfactorily due to monoply, discretion and corruption in the water sector. The water bureaucracy has yet to make the vital mental transition from that of

nonMachine trial version

builder to that of manager. The "*warabandi*" distribution system favors head-enders and discriminate tail-enders, which has serious implications for equity and crop productivity. Within watercourses, tail-enders get 20% less water than middle-enders, who in turn get 20% less water than head-enders. Similar trends are seen in the productivity levels of head, middle and tail-enders of the same watercourse.

Degrading Water Infrastructure

Pakistan benefited immensely from the major water infrastructure built in the Indus Basin. The benefits from Tarbela dam substantially exceeded those which were predicted at the time of construction (World Bank, 2007). Through forward and backward linkages in the economy, the total benefits were probably about twice those of the direct power and irrigation benefits. However, with age and neglect, much of the water infrastructure is in poor shape resulting in huge system losses and low performance in carrying water to the tail reaches of the canal commands. Many elements of the vast hydraulic system are now reaching the end of their design lives, and have to be rebuilt/rehabilitated. There is an enormous backlog of deferred repair and maintenance. Most of the recent irrigation and water supply "investments" have been for the rehabilitation of poorly maintained systems and not for the construction of new infrastructure.

Degradation of the Resource Base-soil Salinization

There is abundant evidence of wide-scale degradation of the natural resource base. The Indus Basin is faced with a considerable salt balance problem. The salts are brought in by rivers and their tributaries. On an average, about one ton of salts is added to each hectare of irrigated land. This accumulation is the main cause of land salinization. Salt-affected soils have become an important ecological problem in the Indus Basin—an estimated 4.5 million ha are already afflicted, about half of which are located in irrigated areas (Qureshi et al., 2004). Of course, the scale of the problem of salt accumulation in the root zone would be even greater if saline groundwater is used for irrigation.

Figure 1 shows that problems of salinity are more serious in the Sindh where about 54% area is saline. The main reason for higher salinity in the lower parts is low rainfall, high evapo-transpiration rates with shallow and saline groundwater. Groundwater is used for irrigation both in isolation and in conjunction with the canal water. The conjunctive use of surface water and groundwater is now practiced on more than 70% of the irrigated lands of Pakistan resulting in soil salinity problems.

pdfMachine trial version

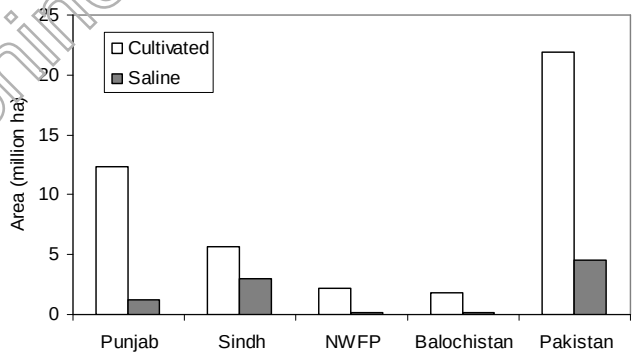


Figure 1: Province-wise distribution of cultivated area and salt-affected area (WAPDA, 2007).

Over-exploitation of Groundwater

Over the past three decades, farmers have largely taken the problem of surface water scarcity into their own hands, and "solved it" by sinking hundreds of thousands of tubewells to feed their thirsty crops. The number of private tubewells have increased from 10,000 in 1960 to about 0.6 million in 2002 (Qureshi et al., 2003) and about 0.8 million in 2006 (World Bank, 2007). The total groundwater abstraction from these tubewells is estimated at 51 x 10^9 m^3 against a recharge of 40-60 x 10^9 m^3. The management challenge is to stabilize the groundwater table at levels where the cost of pumping is affordable. Over-exploitation of groundwater has already caused severe water table decline in most canal command areas of Punjab and Sindh provinces (Figure 2). The average decline in groundwater table is about 1.5 meters per year. The excessive use of groundwater in cities has also led to falling water levels and contamination.

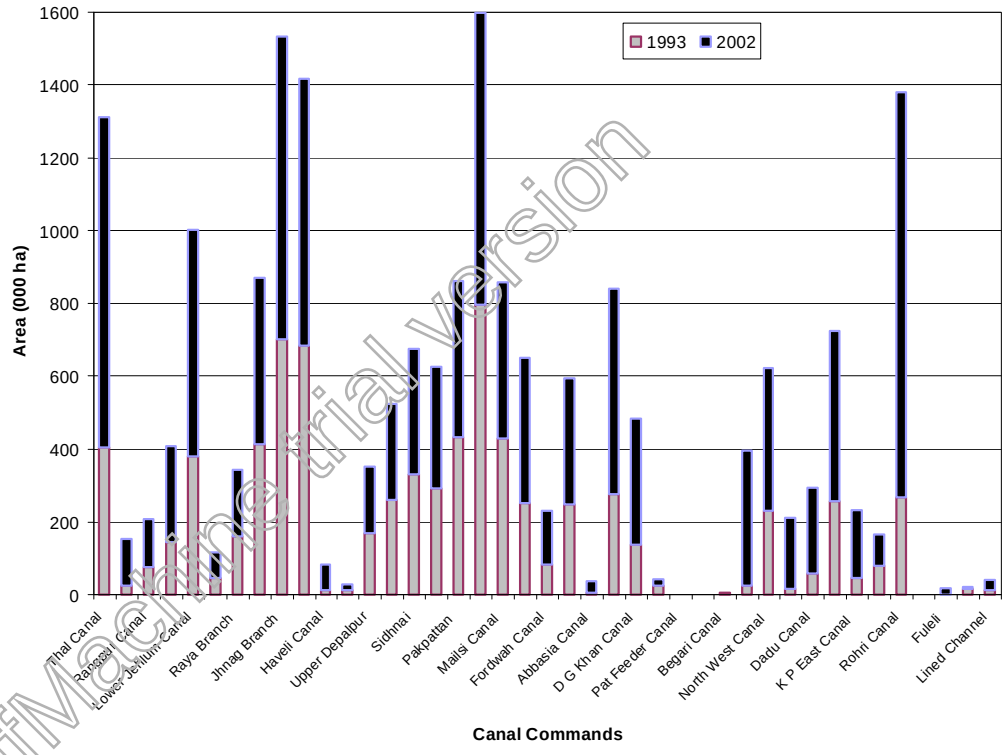


Figure 2: Increase in area with a groundwater table depth of 300 cm between 1993 and 2002.

pdfMachine trial version

Deteriorating Surface Water and Groundwater Quality

There is large-scale uncontrolled pollution of surface water and groundwater from the increasing quantities of pesticides and fertilizers used in agriculture and by rapidly growing cities and industries. Major cities have inadequate sewage treatment plants. Many are either non-functional or working poorly. And there is only one industrial common effluent treatment plant working in the whole of the country. The result is the presence of heavily degraded surface water around all cities and towns.

The quality of groundwater in the Indus Plains varies widely, both spatially and with depth and is related to the pattern of groundwater movement in the aquifer (Qureshi et al., 2007). The salinity of the groundwater generally increases away from the rivers and also with depth. In Punjab 23 percent of the area has hazardous groundwater quality, while it is 78 percent in Sindh (Haider, 2000).

An Inadequate Knowledge Base

The Indus Basin is a single, massive, highly complex interconnected ecosystem, upon which man has left a huge footprint. In a system so massive and complex, the generation and smart use of knowledge are the keys to adaptive management. But there has been very little investment in Pakistan in building this knowledge base and the accompanying institutional and human systems. This is going to be a major constraint in the future when we seriously embark on implementing our strategy. In the past Pakistan has relied heavily on outside knowledge, especially in sciences. Now Pakistan needs to develop its indigenous capacity and make a major push to establish and nurture a new set of institutions that will provide the scientific, technical and policy support for the management of increasingly scarce water.

Non-development of Areas Outside the Indus Basin

The food insecurity-poverty nexus is also pervasive in Pakistan. Poverty in Pakistan, as is the case with most developing countries, is linked to overall growth performance of the agricultural economy. In Pakistan, poverty in irrigated areas is usually attracted by non-irrigated areas. In earlier days of irrigation people migrated from water poor areas to the basin to settle and develop lands. Limited water availability now no longer allows for such migration. The alternate is to develop water resources in those areas outside the basin and offer more livelihood opportunities in their own environment. It is worth mentioning that about 20% of the total water resources of Pakistan are located outside the Indus basin. Therefore it is important to invest in spate irrigation structures in these areas to improve water access for agriculture.

The Way Forward-Key Areas to Focus

The problems of water resources management in Pakistan are complex and a straightforward solution seems impossible. In order to increase agricultural production and ensure sustainability of irrigated agriculture, the overall strategy should be to increase water capital and make better use of water. For quick response to water and food security needs, issues of increased water and land productivity, water delivery

pdfMachine trial version

efficiency and environmental and ecological sustainability, the following options can be considered:

Increasing storage capacity and modernizing irrigation infrastructure

Relative to other arid countries, Pakistan has very little water storage capacity that is hardly 15% of the annual river flow. The per capita water storage capacity in Pakistan is only 150 cubic meters as compared to over 5,000 cubic meters in USA and Australia and 2,200 in China (Figure 3). The dams of the Colorado and Murray Darling rivers can store 900 days of the river runoff, South Africa can hold 500 days in the Orange River and India between 120-220 days in the Peninsular Rivers. In contrast, Pakistan can hardly store 30 days of water in the Indus Basin (World Bank, 2006). If no new storage is built in near future, canal diversions will remain the same and the shortfall will increase by 12 percent in the next decade. The Pakistan Water Sector Strategy estimates that Pakistan needs to raise its storage capacity by 22 BCM by 2025 in order to meet the projected requirements of 165 BCM.

In the past few years, government is emphasizing more and more on the construction of small dams to provide irrigation facilities to the small scale irrigation schemes. The small

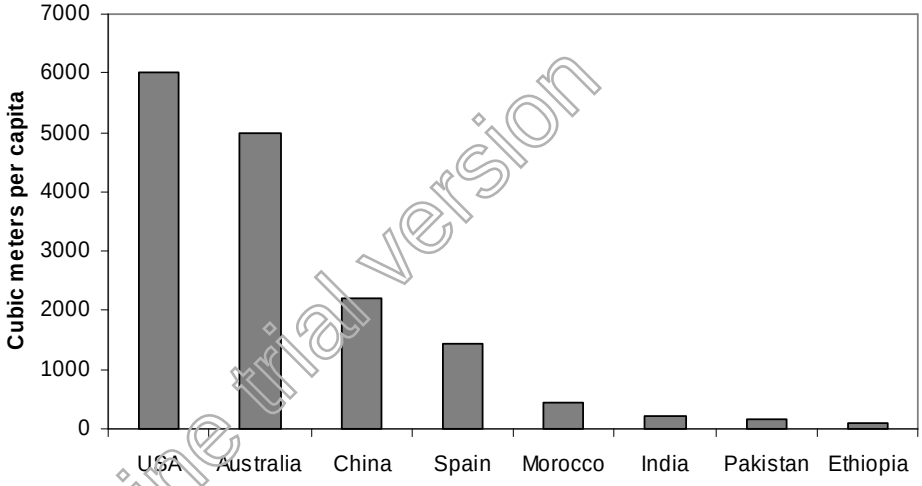


Figure 3: Storage per capita in different semi-arid countries.

dams may address to some extent the poverty issues in selected villages but would not help in eradicating poverty in large areas. The envisaged small dams will have a storage capacity of about 1850 cubic meters, which is good to meet the requirements of small scale irrigation and meet domestic water requirements. But in no way can they be considered as true replacement for large dams. For instance, to store water equivalent to Kalabagh dam we would need to construct 750 small dams, and that too will be exclusive of power generation. Therefore, where it is necessary to build small dams, the importance of large dams should not be ignored as they are imperative for sustained national economic growth.

PDFMachine trial version

Another area which is linked with the agricultural development and needs immediate attention is the construction of farm to market roads so that farmers can bring their produces directly to the competitive markets. Pakistan's post harvest storage and processing industry is also very weak and need to be strengthened. More than 20% of the agricultural products are wasted due to non-availability of proper storage and post harvest processing facilities. Construction of grain storages close to larger markets will greatly help in providing farmers security in the post harvest period. With these storages there will also come about financing arrangements for sustaining and increasing their holding capacity, which today with its absence leads to disproportionate profits for the middleman.

Improvements in the water use efficiencies

The productivity of water in Pakistan is about the lowest in the world. For wheat for example it is 0.5 kg/m^3 as compared to 1.0 Kg/m^3 in India and 1.5 Kg/m^3 in California (IWMI, 2000). The maize yields in Pakistan are very low and there is a tremendous scope for substantial improvements in the maize yields. In terms of water productivity, maize has a factor of nine between lowest in Pakistan (0.3 Kg/m^3) and highest in Argentina (2.7 Kg/m^3). The flip side of current low water productivity is that Pakistan can get much more product – crop, jobs and income – per drop of water. Introducing improved cultural practices such as precision land leveling, zero tillage, bed and furrow planting can help a great deal in improving water productivity.

Managing groundwater in irrigated and rain-fed (barani) areas

Over the last few decades, the water economy of Pakistan has survived largely due to the tapping of the unmanaged groundwater by millions of farmers. It is clear that this era of "productive anarchy" is now coming to an end. There is an urgent need to develop policies and approaches for bringing water withdrawals into balance with recharge. Because the longer it takes, the greater would become the depth of the groundwater table, and the higher would be the costs of the "equilibrium" solution. Also reform in water allocation process to the canal commands is urgently needed if benefit of conjunctive use is to be derived in the basin. Managing the aquifer will require a well thought-out, pragmatic, patient and persistent strategy. In rain-fed areas, farmers have invested in rainwater harvesting structures for supplemental irrigation and for recharging aquifers. Therefore supporting these initiatives of farmers and helping them to sustain them will be crucial to produce more food and increase current levels of water use efficiency.

Maintaining the resource base—salinity management

Pakistan lacks a good network of drainage system which is essential for evacuating salts from the system. Therefore there is a need to invest in the rehabilitating the existing drainage systems and construction of new drainage system for salinity management in the Indus Basin. This is a major piece of essential infrastructure needed for sustainable irrigated agriculture in the basin and requires to be put in place in the coming decade or so. In the past, too much emphasis has been given to engineering solutions, with very little on the management front. Although engineering solutions help increase cropping

Non-Machine Trial Version

intensities and yields, they fail to stop emergence of similar environmental problems in adjacent areas. There is also a need to focus on action programs for the most seriously affected areas, capacity building for farmers, introduction of groundwater extraction regulations, and promotion of saline agriculture.

Building capacity of individuals and institutions

We need to build a strong natural, engineering and social scientific cadre capable of working with all users in defining the problem, developing solutions, monitoring, assessing and adjusting. This is a capacity which requires a wide range of disciplines – those necessary for understanding climate, river geomorphology, hydraulic structures, surface and groundwater hydrology, sediment management, hydraulics, conflict management, politics, economics and financing. A major emphasis will need to be on developing a better understanding of salinity and formulation of salt management strategies; groundwater recharge; and flood flows. The impending challenges of climate change make it even more urgent to have these institutions in place and satisfactorily performing so that Pakistan can become more self reliant in managing its scarce land and water resources.

Strengthening institutions for change

Agriculture in Pakistan is changing fast. Contract farming is increasing, more progressive and commercial farmers are emerging, high value crops are displacing food grains and increased prices of agricultural commodities are attracting people towards agriculture. But all this can not happen without assured water supply. For this to happen, Pakistan needs to invest in institutions to enable them to take on the future challenges of water management. The capacity of institutions should be developed to undertake systematic sets of legislation and organizational changes to solve entitlement, pricing and regulatory issues. Reforms should aim at solving the management issues as well as delivering benefits to the people because without these strings chances of success will be very limited.

Conclusions and Recommendations

The viability of irrigated agriculture in the Indus basin is threatened by multitude of factors, including seepage from unlined canals, inadequate provision of drainage resulting in water logging and soil salinization in irrigated areas, poor on-farm water management practices, insufficient canal water supplies and use of poor quality groundwater for irrigation and lack of robust policies for the management of land and water resources in the basin. On the other hand, it is estimated that to feed the increasing population, 40 percent more food would be required by the year 2025. It is also perceived that due to decreased investments in the water sector combined with shortage of good quality water and environmental and ecological threats, scope of expansion of irrigation areas will be very limited.

pdfmachine trial version

Pakistan needs to boost production from existing farm lands. This will be possible by increasing the performance of existing irrigation systems and, wherever possible, developing new storage and irrigation systems. In order to increase productivity and

sustainability of the irrigation systems in the basin, an integrated water management approach could be useful to manage available water resources with respect to quality and quantity in view of increasing demands, limited resources, rising groundwater tables and soil salinization. This paper suggests following potential solutions:

- Increase water availability (*develop new storages*)
- Save irrigation water (improve irrigation efficiencies)
- Grow more food with limited amounts of water (improve productivity of water)
- Manage salts in fields and basin (control soil salinization and disposal of excess salts to the sea)
- Improve irrigation water distribution and allocation (enhance reliability, equity and adequacy)
- Institutional and policy changes to support more productive irrigation (accelerate reforms process).
- Increase knowledge base (build capacity of individuals and organizations).

References

ADB, 2002. Water resources strategy study. Draft Report Vol. 1, Islamabad, Pakistan.

Bhutta, M.N. and Smedema, L.K., 2007. One hundred years of waterlogging and salinity control in the Indus valley, Pakistan: a historic review. Irrig Drain 56:581-590.

Briscoe, J., Qamar, U., 2006. Pakistan's water economy: running dry. The World Bank Report, Oxford University Press, Washington, 125 pp.

Haider, G., 2000. Proceedings of the International Conference on Regional Groundwater Management, October, 9-11, Islambad, Pakistan.

IWMI, 2000. Water issues for 2025. A research perspective. Research contribution to the World Water Vision. Colombo. Sri Lanka. International Water Management Institute.

PWP, 2001. Supplement to the Framework For Action (FFA) For Achieveing the Pakistan Water Vision 2025. Pakistan water Partnership.

Qureshi, A.S., M. Akhtar, and Shah, T., 2004. Role of changing energy pricing policies on groundwater development in Pakistan. Journal of Applied Irrigation Science. Vol. 39, No. 2: 329-342.

Qureshi, A.S., M.A. Gill, A. Sarwar, 2008. Sustainable groundwater management in Pakistan: challenges and opportunities. Irrig. And Drain. 57:1-10.

Qureshi, A.S., P.G. McCornick, M. Qadir, Z. Aslam., 2007. Managing salinity and water-logging in the Indus Basin of Pakistan. Agricultural Water Management, 95:1-10.

Shah, T., A. Debroy, A.S. Qureshi, J. Wang, 2003. Sustaining Asia's groundwater boom: An overview of issues and evidences. Natural Resource Forum: 27:130-141.

pdfMachine trial version

Tarar, 1995. Drainage system in Indus plains-An overview. In: Proceedings of the national workshop on drainage system performance in Indus Palins and future strategies, 28-29 January, Vol. II, pp 1-45, Tandojam, Pakistan.

WAPDA, 2007. Waterlogging, Salinity and drainage situation. SCARP Monitoring Organization, Water and Power Development Authority, Lahore, Pakistan.

World Bank, 2007. Punjab groundwater policy - Mission report. WB-SA-PK-Punjab GW Mission report, June 2007. www.worldbank.org/gwmate

Zuberi, F.A., 1997, Integrated Surface and Groundwater Management Programme for Pakistan- Groundwater Resources; Interim Report, IWASRI.

pdfMachine trial version

"SAFE DRINKING WATER AND SANITATION IN PUNJAB"

By

Salman Yusuf [1]



Introduction

This paper is with regard to the challenge of providing safe drinking water & sanitation in villages and small towns in the Punjab. This paper provides a general review of the existing situation in Punjab Province, covering water supply, sanitation and drainage and institutions. Given its general nature, seeks to provide an overview of the existing situation for the province as a whole.

Four different conditions of water availability in Punjab, namely : (Figure 1)

- Sweet water areas
- Brackish water areas
- Water scarce areas
- Areas in which water is both scarce and brackish.

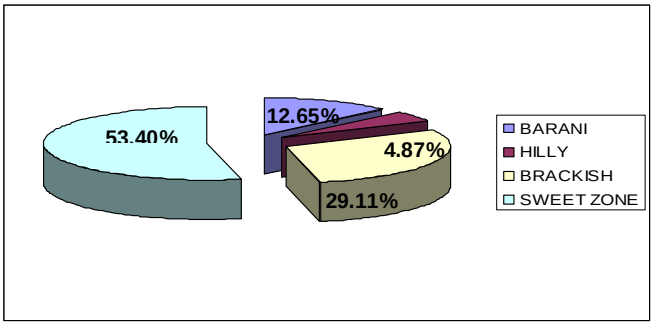


Figure 1 : Different Conditions of Water Availability on Punjab

pdfMachine trial version

1. Deputy Secretary (Technical) Housing Urban Development & Public Health Engineering Department

These classifications mainly relate to groundwater and sweet water is normally available from surface sources in areas with brackish groundwater. As a general rule, it can be said that sweet and brackish water areas occupy the central Punjab plains that are watered by the five rivers while water scarce areas, including those in which groundwater is brackish, are found in the Salt Range/Potohar Plateau and Southern Punjab desert areas.

The water supply section contains sub-sections dealing with water sources, completed and ongoing initiatives, water supply coverage and water system management arrangements. The sanitation and drainage section contains sub-sections dealing with sanitation, drainage and waste water treatment coverage, institutional arrangements and innovative initiatives. An overview of existing water quality, water supply and drainage related norms and standards.





pdfMachine trial version

1. Water Supply

1.1. Water Sources

Possible sources of water for human consumption include:

- Rainwater
- Surface water (in streams, rivers and lakes)
- Springs
- Groundwater

Rainwater can be collected from roofs, normally by individual households, or from protected ground level catchments. Collection from roofs is not widely practiced in Pakistan, partly because rainfall is highly seasonal and partly because houses are mostly built with flat roofs rather than the sloping roofs that are most suitable for rainwater collection. Ground level catchments are possible in hilly areas. Indeed, some towns collect water from dammed catchments. However, water collected in this way normally has to be treated. Given the difficulty in ensuring effective treatment of contaminated water and the large catchments required to provide water at the village level, ground level rainwater catchments will not normally be a preferred water source option.

Surface water is available throughout the Punjab plains in irrigation canals and the five major rivers. As indicated in the previous paragraph, it is subject to contamination and must be treated to remove pathogens before it can be considered fit for drinking. In the 1980s, a number of PHED village water supply schemes in brackish groundwater areas relied on water drawn from minor irrigation canals and treated by sedimentation and slow sand filtration. Few if any of the slow sand filter works have been operated and maintained properly and those that are still operational are mostly by-passed.

Springs are a possible source of water in hilly areas and a few spring-fed schemes exist in the Potohar Plateau area and in the Districts that lie west of the Indus. Where springs exist, they can provide good quality water as long as they are properly protected. However, they will be an option in only a small number of cases.

Most people in Punjab obtain water from groundwater sources. In sweetwater areas, most households access shallow groundwater through shallow wells and relatively shallow tubewells fitted with handpumps or, for richer households, electrically powered pumps. Where village schemes exist, they obtain water from tubewells, which draw from deeper depths than most individual household wells and tubewells.

In brackish water areas, many villages located close to larger canals and rivers rely on seepage water, tapped by relatively shallow tubewells located close to the banks of the

pdfMachine trial version

canal or river. This approach can also be used for villages situated some distance from the canal or river, provided that a transmission main is provided between the well or wells and the village.





pdfMachine trial version

In hilly and relatively dry areas, water is obtained from shallow aquifers, normally consisting of alluvial sands and gravels located beneath seasonal water courses. Such sources are normally located some distance from the village or villages to be served. In such circumstances, multi-village systems might be considered but the normal practice at present is to provide each village with its own system, even though several village systems may rely on the same aquifer.



pdfMachine trial version

Percolation wells from several villages - Chakwal District

Percolation wells, are commonly used to access water from shallow gravel/sand aquifers. Another option, which may be combined with a percolation well, is to construct infiltration galleries under the bed of the watercourse. The dam blocks the flow of

groundwater, leading to increased groundwater depth and greater yield from an infiltration gallery located upstream of the dam. This system will only be economical where the width of the valley and the depth to impervious rock or clay are both limited so that the sub-surface dam can be built fairly cheaply.

1.2. Completed and Ongoing Initiatives

In the 1980s and early 1990s, the PHED constructed a large number of rural water supply schemes, most of which relied on either treated canal water or tubewells. More recently, the most important initiatives have been the Punjab Rural Water Supply and Sanitation Project (PRWSSP) and Punjab Community Water Supply and Sanitation Project (PCWSSP), both of which were funded by the Asian Development Bank (ADB). PRWSSP ran from 1995 to 2002. It covered seven districts, mainly in relatively water-scarce areas and including Chakwal District and resulted in the implementation of about 335 schemes.

PCWSSP, which ran from 2002 to 2007, built on the PRWSSP experience, extending the remit to cover 30 districts and paying increased attention to social mobilization. The Project Completion Report on the second phase of PCWSSP states that 778 subprojects were implemented, providing 161,132 household connections and serving a population of 2,621,192. These figures suggest an average of just over 206 household connections per scheme and about 16 users per connection. In addition, about 100 schemes that had been wholly or partially prepared by the PCWSSP team are said to have been implemented by the PHED with government funds.

The National Ministry of Environment initiated a 'Clean Water for All' programme in 2005. Under this programme, which was included in the 2005 – 2010 Mid Term Development Framework, water treatment plants were to be provided in 6035 locations throughout Pakistan, one plant for one union council. The water treatment plants come in three standard designs with capacities of 500, 1000 and 2000 gallons per hour, approximately 2.25, 4.5 and 9 cubic metres per hour respectively. It appears that they incorporate ultrafiltration membranes and disinfection using ultra-violet light although details have not been confirmed. The programme became part of the Government's Khushal Pakistan Programme. Preliminary calculations suggest that 10 hours operation of the 9 cubic metres per hour plant would provide approximately 10 litres per person per day to a village with a population of 9000, sufficient to provide drinking water but insufficient for all potable water needs.. The approach has several serious drawbacks. First, it provides water at a central point within each Union Council and is only easily accessible to people living close to this central point. Second, it requires that people carry water from the delivery point to their houses. Given that research has shown that the greatest possibilities of contamination occur during transport to and storage in the home, this means that the claimed health benefits are unlikely to be achieved in practice. Third, there must be considerable doubt about its sustainability. Membrane filtration

pdfMachine trial version

systems require regular maintenance and cleaning, without which their capacity reduces so that they fail to produce much water after only a few months. For all these reasons, the small water treatment plant option, as implemented in the Clean Water for All programme, will not be considered further as a model to be replicated throughout Punjab.

1.3. Water Supply Coverage

According to the Multiple Indicators Cluster Survey (MICS) 2003–2004, access to improved drinking water sources is consistently high across all districts of Punjab. Indeed, the MICS estimates a provincial average of 97%. These are overall figures and include many people who obtain their water from self-financed shallow wells and tubewells. Most of these sources draw on relatively shallow water sources, some of which may be contaminated. In addition, information on water quality in piped water schemes suggests that many are subject to pollution in the distribution system. Taken together, these points suggest that considerably less than 97% of the population has access to an adequately improved water source.

1.4. Water Quality

PCRWR has conducted a survey of water resources throughout Pakistan. This survey has involved the collection and testing of one or two water samples from water sources in every union council. Parameters tested include bacteriological contamination (+ve or –ve), colour, odour, taste, total dissolved solids (TDS – a measure of salinity), arsenic, hardness, nitrate (an indicator of organic pollution and potential cause of 'blue baby' syndrome) and fluoride.

The 2009 ADB Impact Evaluation on PRWSSP and PCWSSP reports that 45% of samples taken at source and 72% taken in the distribution system were contaminated with coliform bacteria. The increased percentage of contaminated samples from the distribution system is not surprising but the 45% figure for samples taken at source is higher than might be expected, given the depth to the aquifer and the nature of the subsoil. This requires further investigation. None of the 115 schemes assessed had problems with high arsenic concentrations and only three had fluoride concentrations in excess of the recommended standard.

A summary report by the PCRWR states that Total Dissolved Solids (TDS) concentrations in groundwater range from less than 1000 mg/l near the major rivers to over 3000 mg/l, indicating highly saline conditions, in the areas between the rivers. Cholistan Desert in the Southern Punjab and covering part of Bahawalnagar District is underlain by highly brackish waters which cannot be used for drinking purposes.

Arsenic contamination occurs in some areas of Punjab. Muzzafargarh, one of the study Districts, is one of the affected areas. A study conducted by researchers from UNICEF

pdfmachine trial version

and other institutions[1] found that 58% of 49 samples taken from both shallow and deep groundwater exceeded the WHO guideline standard of 10 µg/l. No samples taken from shallow aquifers had arsenic levels above 25 µg/l but all seven samples taken from deeper groundwater had arsenic levels above 50µg/l, the figure that is accepted as the absolute maximum limit by several countries, including India and in some Pakistan guidelines[2]. The report suggests that the arsenic contamination in shallow groundwater may be at least partly due to the release of arsenic following the reduction of hydrous ferric oxide (HFO) driven by pollutant organics contained in sewage and other anthropogenic pollutants. Overall, the study found that the greatest problems were likely to occur close to industrial towns. UNICEF also tested for arsenic in other Districts, including Chakwal and Gujrat, Its first survey found that 90% of samples had arsenic concentrations within WHO limits and that only 2% were above 50µg/l. The percentage above this figure was 5% for Gujrat and zero for Chakwal. There is little epidemiological evidence for arsenic poisoning in Punjab but UNICEF nevertheless recommended that potential water sources should be tested for arsenic.

There are also reports of high fluoride content, ranging from 65 to 12 mg/l in groundwater in Bahawalpur area. A report by the British Geological Survey (BGS) found some evidence of fluoride contamination in groundwater, most of which appeared to be occurring around cities and industrial areas.

Nitrate contamination, particularly of shallow groundwater, could be a problem where either unsealed waste water ponds or excessive use of nitrogen-based fertilizers results in percolation of nitrogen-rich water into the ground. However, the available evidence suggests that nitrate levels in groundwater are generally within the PSQCA standard of 10mg/l. A WaterAid document[3] reports the findings of Chandio (1999) that concentrations of nitrate (NO_3-N) were mostly less than 6 mg/l in dug wells and tubewells from canal-irrigated areas of Pakistan, although concentrations up to 210 mg/l (as N) were found where directly contaminated by sewage.

pdfMachine trial version

Institutional Responsibilities and Management Arrangements

Prior to devolution, the PHED and Local Government, Elections and Rural Development Department (LG&CDD) were responsible for implementing water supply & sanitation schemes. Their responsibilities were as follows:

- LG&CDD - small-scale water and sanitation schemes in rural communities, including hand pump installations, and promotion of household sanitation

[1] See Nixon R, McArthur J, Shrestha B, Kyaw Myint T and Lowry D (2004), Arsenic and other drinking water quality issues, Muzzafargarh District, Pakistan, *Applied Chemistry,* Elsevier

[2] See Section 2.4.13 of PDSSP Technical and Service Delivery Standards for Water Supply and Sanitation Sectors (2008).

[3] Information Sheet on Groundwater Quality in Pakistan, produced for WaterAid by British Geological Survey –(http://www.wateraid.org/documents/plugin_documents/pakistangroundwater_1.pdf)

- PHED - relatively large and complex water supply and drainage schemes in larger settlements.

Most of the systems implemented by the PHED were groundwater-based but those in areas with brackish groundwater relied on canal water treated by sedimentation and slow sand filtration. Most PHED systems had three staff, an operator, a valve man and a watchman, all of whom were PHED employees. Each system had its own bank account, which was managed by the PHED Sub-Divisional Officer (SDO), who was the signatory for the account. Customer payments were deposited into this account and salaries, electricity bills and other bills incurred in operating the system were paid from it. In 1993, Government in Pakistan adopted a Uniform Policy, which stated that operation and maintenance of rural water supply schemes should henceforth be the responsibility of beneficiary communities. The Government of Punjab enacted legislation to implement this policy in late 1993. The policy required PHED to mobilise communities to form water users committees (WUCs) to take over schemes after completion according to the terms of a Memorandum of Understanding (MOU) between the PHED and the WUC. Funds were to be deposited in a joint account, in the names of the SDO PHED and a member of the WUC. The PHED would continue to be responsible for the planning and design of new schemes and also undertook to train community personnel in the technical and financial skills required to operate schemes.

In 2001, the Punjab Local Government Ordinance (PLGO) assigned responsibility for water supply and sewerage services to Tehsil and Town Municipal Administrations (TMAs). PHED's role was initially restricted to monitoring although more recently it has reclaimed most of its responsibilities for planning, design and implementation. The PLGO makes no direct reference to the options for community management. It does state that a TMA can assign or contract out any of its functions to any public-private, public or private organisation, subject to the approval of the Tehsil Council and after inviting public objections. In practice, investigations in Jaranwala Tehsil suggest that schemes previously operated by the PHED were left with little support. By 2004, around 35% of existing schemes in the tehsil were non-operational. The situation was worse for systems based on slow sand filter treatment of canal water. Of about four schemes investigated, only one was operational and even this was barely functioning with no the slow sand filters effectively by-passed.

An evaluation of the two projects was recently carried out by the Asian Development Bank's Independent Evaluation Department (ADB 2009). The study covered 115 villages, representing about 10% of all the schemes covered by the two projects. It revealed that 68% of PRWSSP schemes and 89% of PCWSSP schemes remained functional, giving an average of 80% functional overall. The higher percentage of failed PRWSSP schemes does suggest a negative relationship between age of scheme and operability. This impression is reinforced by another study finding, that only 43% of the community organisations formed to manage rural water supply schemes under the two projects were still partly or fully functional. The study report identified a positive relationship between scheme functionality and a lack of alternative water resources. Our

pdfMachine trial version

initial investigations provide qualitative confirmation of this conclusion. It seems that most water supply schemes in Chakwal District, a water scarce area, are operating well with good cost recovery and a strong likelihood that services will be sustained.

While the majority of functional schemes are managed by community organisations, as required by Government policy, the management arrangements for the schemes serving Balkasar and four other villages in Chakwal District are in reality closer to those that might be found in a small private sector water company. Further information on the management arrangements for the Balkasar schemes is given in Box 1.

The Punjab Local Government Ordinance (PLGO) does not specifically mention the policy of community management. It assigns responsibility for planning and providing water supply and drainage schemes to Tehsil Municipal Administrations (TMAs). In practice, TMA investment in water supply since 2001 has been limited and what investment there has been has generally been small-scale, involving piecemeal extension of existing systems. The ADB evaluation of 115 schemes executed under PRWSSP and PCWSSP found no systematic arrangements for recording income and expenditure. In contrast to this general finding, visits to two metered systems in Chakwal District revealed well maintained records of water use, billing and payments. In Balkasar, accounts have been computerized.

Box 1 The Balkasar Initiative

The water supply scheme serving Balkasar was commissioned in 1983 and a Water User Committee took responsibility for operation in 1988. The WUC operated the scheme for a number of years but began to face problems as unequal distribution of water, resulting from the varied topography of the supply area, led to many households ceasing to pay their bills. Poor cost recovery resulted in losses, which were met from maintenance funds handed over by PHED when the WUC took over responsibility for the system. Efforts to improve the situation by dividing the system into different supply zones and raising the tariff proved to be ineffective. Cleary this situation could not be sustained. In 1997, a decision was taken to install meters and all supplies were metered by 2001.

The number of connections has increased over the years from around 300 in the late 1990s to around 1100 today. Water is drawn from three linked percolation wells located about 2km from the village. From the central well, it is pumped to a ground level service reservoir located in the centre of the village. From this reservoir, which provides approximately 24 hours storage at the average daily demand, it is pumped to two elevated service reservoirs, from which water gravitates to the village on a continuous 24/7 basis. Supply to private sector and bulk users located some distance from the village is by a separate main, and is not continuous. Rather continuity of supply is achieved through the storage capacity provided in-house by the various customers.

The system has been upgraded and improved over the years. For instance, the ground level reservoir was not included in the original scheme and the second elevated service reservoir has been constructed fairly recently. A second supply main has recently been laid from the source to the ground level reservoir. Mr Moussadeq, the Chairman of the Balkassar WUC (and in effect operator of the scheme), says that the funds for these

Draft working final version

improvements and extensions, including the extension to serve commercial areas close to the motorway, have been raised by the organisation itself. However, it seems that Rs 458.000 in CCB funds provided by Chakwal TMA was used to fund the second supply main and it may be that the WUC has also sought funding for some other improvements from external sources.

In addition to the Balkasar scheme, Mr Moussadeq's organisation is also operating four smaller village schemes in the vicinity of Balkasar. The organisation currently employs seventeen staff. An accountant, three meter readers and three complaints resolution staff divide their time between all five schemes while the remaining 10 staff are pump operators, who work 8 hour shifts in the five villages.

Current tariffs are:

- Rs7 per cubic metre for domestic connections.
- Rs13 per cubic metre for commercial connections.
- Rs 6 per cubic metre for bulk supplies to institutional customers.

Sanitation and Drainage

1.5. Sanitation, Drainage and Waste water Treatment Coverage

Figures on sanitation coverage in Punjab vary, reflecting the difficulty of determining what exactly constitutes good sanitation. The Pakistan Social and Living Conditions Measurement Survey (PSLM) for 2006-7 gives overall sanitation coverage, urban and rural, as 73%. Corresponding figures from the 2006 Human Development Report and Joint Management Programme survey 2008 are 59% and 58% respectively, reflecting the fact that the last two are rather stricter in determining what constitutes satisfactory sanitation. Percentage coverage for rural areas is generally much lower than that for towns, the rural figure for the PSLM being only 56% for instance. These figures are averages and there are likely to be great varieties between Districts. The PSLM survey found that the average sanitation coverage figure for Rajanpur District, one of the study Districts, was only 28%.

Regardless of the situation with regard to toilet coverage, the drainage situation is generally unsatisfactory. Few villages have any form of sewerage and most rely on open drains. Pour-flush WCs may be connected to these drains directly or may discharge indirectly via septic-tanks. Figure 2 show a typical situation in the centre of a village, with open drains running down either side of a brick-soled lane.

pdfMachine trial version



Open drains in Kotla Arab Ali Khan, Gujrat District

There are a few exceptions to the general rule. In Lodhran District, some villages have piped sewerage, provided by householders themselves with support from the Lodhran Pilot Project, a non-government organisation that follows the approach pioneered by the Orangi Pilot Project (OPP). Similarly, in the area around Faisalabad City, Anjuman Samaji Behbood, an NGO led by Mr Ahmed Nazir Wattoo, has implemented some rural sewerage schemes following the OPP approach. Other than these initiatives, which are small in the overall scheme of things, the PHED does cover some collector drains.

Few drainage schemes incorporate pumping and virtually no waste water from villages and small towns is treated. A significant percentage of waste water finds its way to ponds, from which it may drain and evaporate away although it is probably more common for waste water to overflow out of the pond or be pumped out of the pond for irrigation purposes. Studies by the International Water Management Institute (IWMI) suggest that 26% of all Pakistan's vegetable production relies on irrigation with waste water. Waste water may also be used to irrigate wheat although farmers in Gujrat District report that waste water irrigation has an adverse effect on rice cultivation. (Irrigation of rice paddy is also likely to have high health risks for workers). Although waste water irrigation occurs widely around larger towns and cities, there is no doubt that it is also found around villages. Some waste stabilisation ponds were provided under PCWSSP. Anecdotal evidence suggests that effluent disposal can be particularly problematic during the monsoon months and at harvesting times, when farmers do not want waste water and may block sewers and drains to prevent it from reaching their fields. (Figure 3)

pdfMachine trial version



1.6. Institutional Responsibilities for Sanitation

Responsibilities for sanitation are less clear than those for water supply. Until 2001, the LG&CDD was theoretically responsible for promoting improved household sanitation but the reality seems to be that its promotional activities were very limited. In practice, most households with sanitation have provided their own facilities, which normally consist of a pour-flush toilet discharging to an open drain.

The Punjab Local Government Ordinance (PLGO) requires Union Councils to maintain public sources of drinking water, including wells and ponds, and presumably by this token requires them to keep such sources free of contamination. However, there is no specific reference to promoting better sanitation. Similarly, TMAs are required to provide sewerage and sewage disposal infrastructure but the PLGO makes no reference to sanitation promotion. The PLGO says nothing on the specific responsibilities of District (Zilla) Councils.

DoMachine trial version

Levels of Service and Standards

1.7. Drinking Water Quality Standards

The PDSSP Technical and Service Delivery Standards for Water Supply and Sanitation provide a wide range of information on different water quality standards. For planning and design of the proposed model water supply schemes, the Pakistan Standards Quality Control Authority (PSQCA) standards may be taken. These are generally based on WHO standards. PHED also has its own standards and where these are more

stringent than the PSQCA standards, they should be followed. Standards with particular relevance to work on model schemes are listed in Table 1 below:

Table 1 - Some key drinking water quality standards

Pollutant	Unit	PSQCA		PHED	
		Desirable limit	Permissible limit	Desirable limit	Permissible limit
Total dissolved solids	mg/l	1000	1500	500	1500
Total hardness (CaCO3)	mg/l	20	500	100	500
Ph		7 – 8.5	6.5 – 9.2	7 – 8.5	6.5 – 9.2
Fluoride	mg/l	1.0	1.5	Not given	
Iron	mg/l	0.3	1.0	0.1	1.0
Manganese	mg/l		0.5	0.05	0.5
Nitrate (NO3)	Mg/l		10	Not given	
Arsenic	µg/l	10	50	Not given	
E.Coli		0/250ml		Not given but PHED aims to follow WHO standard (See below)	
Total coliform		0/250ml			

In some Districts, arsenic concentrations in shallow groundwater may exceed the 10 µg/l figure. It appears that this is generally considered acceptable, if not desirable, so long as the concentration does not exceed 25 µg/l. Indeed, the PWSSP Technical and Sewerage Delivery Standards note that many countries, including India and china, arsenic concentrations up to 50 µg/l are accepted in drinking water and suggest this figure as a permissible upper limit for Punjab. (1 µg/l is equivalent to 0.001mg/l).

The WHO bacteriological standards require that in 95% of the samples collected over a one year period, coliforms should be absent from 100ml of the sample. No sample should contain more than 10 coliforms per 100ml and no sample should contain escherachia coli (e.coli) in a 100ml. Coliform bacteria should not be detectable in two consecutive samples. The available information suggests that these standards are not being met by many rural water supply schemes at present. The aim should normally be to achieve the standards at the source and ensure that schemes are planned, designed and constructed in a way that minimises the risk of pollution occurring in the distribution system. This will require that pipes are durable and joints and connections are made in a way that ensures that the system is watertight.

pdfMachine trial version

1.8. Water Supply Technical Standards

The water supply technical standards as set out in the PDSSP Technical and Service Delivery Standards document are generally appropriate. However, some aspects of the standards should be reviewed. These are discussed below.

Assumed design life The design lives adopted for tubewells and water treatment facilities are based on the perceived operational life of those facilities. So, a design life of 15 years is adopted for tubewells on the basis that 15 year old tubewells are still operating satisfactorily while that for slow sand filters has been taken as 20 years on the basis that slow sand filters commissioned in the mid 1970s remained operative until the mid 1990s. This reasoning pays insufficient attention to the fact that the performance of a facility depends to a large extent on the way in which it is operated and maintained. Slow sand filters have been operating in London for over 100 years and continue to operate today. A distinction needs to be made between mechanical machinery, which should normally be designed for a life of 10 or at most 15 years, and civil works, which if properly designed and constructed may have a design life of 50 years or more. In the case of water mains, the design life depends on the material used. The PDSSP standard of a 20 year design life for distribution mains may be appropriate for galvanised steel mains but the design life of uPVC and particularly high density polyethylene (HDPE) mains should be longer, up to 50 years in the case of HDPE although it may be appropriate to take 30 years for financial comparison purposes. This is important as it will influence the economic calculations on which pipe material decisions are made.

Per-capita consumption The current PHED standards suggest that the design figure used for per-capita water consumption should increase with increasing design population in accordance with the following norms:

Design Population	Per-capita consumption - gals per day (including allowance for unaccounted for water)
Up to 5000	10 gallons
5,000 – 10,000	15 gallons
10,000 – 25,000 (without sewerage)	20 gallons
10,000- 25,000 (with sewerage)	30 gallons
25,000 – 100,000 (without sewerage)	40 gallons
25,000 – 100,000 (with sewerage)	50 gallons

pdfMachine trial version

The PDSSP standards propose that these norms should be replaced with one standard, that all schemes should be designed to achieve 50 gpcd. In principle, the PDSSP approach is sound. There is no reason in theory why people in a village of 4000 people should use less water than those in a town of 30,000, assuming that water is freely available in each case. Similarly, there is no theoretical or practical reason why water consumption in households with sewer connections should be greater than that of households served by pucca open drains. However, the figure of 50 gpcd is arguably much too high. It would mean that per-capita water production for domestic purposes will be higher than in many European countries and would require huge investment in water production facilities in order to meet the water supply needs of all of the population.

Actual average water consumption for metered schemes is much less. For instance, taking the average bill for Balkasar as Rs80 per month and the current domestic rate of Rs7 per cubic metre, average water-use is about 11.5 cubic metres per month. This equates to about 1500 litres per person for an average household size of 7.5, which in turn equates to an average daily demand of 50 litres (11.2 gallons) per person per day. This figure is only slightly above the current PHED design figure for villages with a population of less than 5000. This figure does not include allowance for leakage. The leakage figure for Balkasar is said not to exceed 5% but even allowing for a higher percentage leakage, say 20%, per-capita consumption will still be less than the 15 gpcd figure allowed by the PHED for schemes serving a population of up to 10,000.

Bearing these points in mind, it is suggested that the design standards for 'model' schemes should be 20 gpcd for metered schemes and 25 gpcd for unmetered schemes. These standards allow for some increase in consumption over the average currently measured for metered schemes.

Draft Machine trial version

Peak factors The PDSSP standards propose that the peak daily demand should be taken as 1.5 times the average daily demand and that the peak hour factor should be taken as 1.5 times the peak daily demand, giving a combined peak factor of 2.25. These are fairly standard figures and are likely to be appropriate for schemes that deliver water 24/7. It will normally be necessary to use higher peak factors for schemes that deliver water intermittently. For instance, the peak hour factor for a scheme that delivers water for 4 hours a day will be at least 6[4]. If the peak day factor is still taken as 1.5, mains will have to be designed for an overall peak factor of 9. This illustrates one of the key disadvantages of intermittent schemes.

Minimum pipe diameter and cover The PDSSP standards follow the PHED standards in proposing a 3" (80mm) minimum pipe diameter for distribution and transmission mains, apart from in hilly areas where a 1½" (38mm) minimum diameter is recommended. In practice, there appears to be no technical reason why a minimum 50mm internal

[4] Although little evidence is available, it is probably reasonable to assume that flow variations during supply periods are limited for systems that provide water for short periods. So, in the case given, the peak hour factor can probably be taken as 6.

diameter should not be allowed for HDPE mains. PDSSP and PHED recommend a 3ft (900mm) minimum cover over water mains. While this is appropriate for trafficked roads, it may be possible and indeed desirable to reduce the cover in pedestrian lanes to perhaps half this figure, depending on the pipe material and diameter.

Overhead Reservoirs PHED's existing design guidelines state that overhead reservoirs should be provided where needed, with a capacity of 1/6th of the average daily demand, subject to a minimum size of 5000 gallons. The stipulation 'where needed' provides some discretion and many PHED engineers now design schemes that rely on direct pumping and do not include overhead reservoirs. The PDSSP standards state that overhead reservoirs are essential, except where the topography is such that they can be replaced by an appropriately located ground storage tank or tanks. They suggest a minimum capacity of 1/10th of the average day demand and a minimum capacity of 10,000 gallons. The PHED engineers are right to observe that overhead reservoirs may have limited utility on schemes that provide a limited intermittent supply. However, the ultimate aim should always be to provide water on a 24/7 basis and for a 24/7 scheme, overhead storage will be essential. The amount of storage provided will depend on the pattern of supply and demand. Storage equivalent to about 1/4th of the average daily demand is required to balance supply and demand when demand fluctuates over a 24 hour period and the supply is constant over that perriod. Rather less storage is required if the supply capacity is greater than the average daily demand so that supply does not have to be continuous but can be matched to demand. So, the minimum overhead capacity should be decided on the basis of analysis of demand patterns and supply arrangements.

1.9. Sewerage Design Norms and Standards

PDSSP's recommended design lives for civil and electrical/mechanical works, 25 years and 10 years respectively, are reasonable. The design approach for sewers could usefully be reviewed. The peak factors given in both the PHED and PDSSP standards are fairly conventional, following an approach originally developed in the United states. However, measurements of actual flows in European conditions suggest that dry weather flow peak factors are likely to be rather lower, perhaps 2 – 3 for a population up to 5000, reducing to perhaps 1.5 for a population of over 100,000. Conversely, it is unrealistic to allow no provision for storm water ingress in rural areas[5]. In practice, infiltration should not be significant for sewers laid above the water table and can generally be ignored. The PHED and PDSSP manhole standards are almost identical and provide a good basis for manhole sizing. The possibility of using small inspection chambers on shallow branch mains should be further explored. PDSSP and the PHED recommend 3' and 2.5' earth cover respectively over sewers. While the PDSSP figure may be appropriate for sewers laid under trafficked roads, a reduced cover will often be appropriate in narrow non-trafficked lanes. The key point to note here is that the sewer should normally be deeper than the water main. All technical agencies in Pakistan recommend a 9" (228mm) minimum sewer diameter. There is no clear technical reason

PdfMachine trial Version

[5] Both sets of Guidelines are contradictory on this point, stating that sewers will be designed as partially combine and then saying that no allowance will be made for storm water for rural schemes.

for this. A 6" (152mm) diameter sewer will provide more than enough capacity for branch mains, even for sewers designed to carry some storm water[6]. The reason normally given for specifying a larger minimum diameter is that smaller diameter sewers are more likely to block or will block more quickly. In fact, the smaller the diameter of the sewer, the greater will be its hydraulic efficiency for a given flow. It will be worthwhile to consider a revised approach to sewer design, starting from first principles and laying special emphasis on the need to keep unwanted materials and objects out of the sewers. This will require:

- careful attention to manhole and chamber cover design (in order to ensure that extraneous material cannot enter the sewer through broken or missing manhole covers)
- Exploration of alternatives to the presently used reinforced concrete pipes; and
- Consideration of sewer connection arrangements.

A pilot sewerage project is currently being planned and will shortly be executed in two lanes in Lahore's Walled City. This will use 6" diameter uPVC pipes, with 4" uPVC house connections, connected to the main sewer via 'Y' connections rather than at manholes. In the past, 'Y' connections have been considered inappropriate for sewers in Pakistan, partly because they are difficult to fabricate in reinforced concrete. However, they are used widely elsewhere and provide a smoother entry into the sewer and thus better hydraulics than connections at manholes. The performance of the Walled City pilot system should be monitored and, if appropriate, it may be considered for branch mains in rural schemes, perhaps on a pilot basis in the first instance, provided that PVC pipes are used for both sewers and connections.

pdfMachine trial version

Institutions

1.10. PHED Operational Structure

The PHED operates in a partly centralised and partly decentralised way. Technical sanction powers of Executive Engineers working at the District level are limited and so final decisions on all but fairly small schemes can only be made by higher level officials. There is a design section at the headquarters in Lahore and functioning water quality testing laboratories in Lahore, Rawalpindi and Multan. In all these respects, the organisation is centralised, although there have recently been moves to devolve water quality testing to District offices. However, in its day to day operations, the PHED appears to act in an essentially decentralised way. New schemes are identified and prepared at the District level and as such are the direct responsibility of the Executive Engineer and his staff. Once complete, they have to be checked and sanctioned at

[6] Indeed, 100mm (4") diameter sewers are routinely provided in schemes to serve low income areas in Brazil. These schemes are designed on the assumption that sewers will be separate, carrying only foul water, which is unlikely to be appropriate for Pakistan.

higher levels of the organisation but this does not alter the fact that responsibilities for scheme preparation lie at the Executive Engineer level.

Prior to 2001, the PHED was responsible for operation of all water supply schemes that had not been taken over by a WUC. In practice this seems to have meant the majority of schemes. Most systems had three staff, an operator, a valve man and a watchman, all of whom were PHED employees. Each system had its own bank account, which was managed by the PHED Sub-Divisional Officer (SDO), who was the signatory for the account. Customer payments were collected by the pump operator and valve man and remitted to the SDO, who paid them into the account. Salaries, electricity bills and other bills incurred in operating the system were paid from the account. As with design, operational systems thus operated in an essentially decentralised way. The number of failed schemes recorded in the 1990s suggests that this system did not work particularly well.

Since 2001, the PHED has had not remit for operation and maintenance and there are no posts within the structure that deal specifically with operational issues. Whatever the role of the PHED should be in the future, there is arguably a need to develop effective systems and procedures to provide support and oversight to local water supply and drainage system operators.

1.11. Limited Capacity of TMAs

One point to be taken into account when considering possible management arrangements for waste water dispoal, and indeed for water supply, is the limited technical capacity of TMAs. Most TMA staff are untrained and employed at low grades. For instance, only 1% and 3.3% of the staff employed by Rawalpindi TMA in 2004 were above grade 17 and in the range 11 – 16 respectively. No less than 92% of the TMA's staff were at grade 5 or below[i]. This situation is typical and is unlikely to have changed significantly since 2004. The key point is that TMAs do not have capacity to either manage or provide support and oversight for rural and peri-urban water supply schemes. A related point is that TMAs are financially dependent on transfers from higher levels of government and do not have the resources to support operation of village level water supply and sanitation schemes.

pdfMachine trial Version

[i] Source – Rawalpindi Environmental Improvement Program (REIP), Institutional Development Sector Paper, Supplementary Paper 06, prepared by Izhar Ul-Haq, April 2004.

pdfMachine trial version