PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES

Proceedings
of the
National Workshop on Quality of Drinking Water

March 07, 1998
Islamabad, Pakistan

Compiled by
Dr Bashir A. Chandio
Dr Muhammad Abdullah

Jointly Organized by
PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
AND
CHEMICAL SOCIETY OF PAKISTAN

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Pakistan Council of Research in Water Resources (PCRWR) Islamabad

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PREFACE

Water is the fountain of life and is indispensible for its continuity Though it is earth's one of the most abundant substances but is rarely found in its pure form because being a universal solvent it is either a vehicle or storage of various pollutants The consequent scarcity of potable water has created the real problems of human health and environmental sustainability Keeping in view the paramount importance of drinking water, the PCRWR and CSP have put their modest efforts to organize a one day "National Workshop on Quality of Drinking Water" The papers and subsequent discussions have covered a wide spectrum of drinking water quality

I feel immense pleasure to acknowledge the efforts of organizers to conduct this workshop very effectively. I am cognizant that all dimensions of the drinking water quality are not comprehensively discussed in this workshop, however, it gives me greater satisfaction to see that workshop proceedings are properly documented and published. I would put my efforts to bring these recommendation to the notice of planners and decision maker so that future planning carries some flavor of this workshop recommendations

Dr. Bashir A. Chandio
Chairman
Pakistan Council of Research
in Water Resources (PCRWR)

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Dr. Din Mohammad,
Secretary, Workshop Organizing Committee

Syeda Abida Hussain, Federal Minister for Science & Technology
Lt Gen (retd) Javed Ashraf Qazi, Secretary, Ministry of Science & Technology
Dr. Bashir Ahmed Chandio, Chairman, Pakistan Council of Research in Water resources
Professor Roshan Ahmed, Chairperson, Workshop Organizing Committee
Mr Khalil-ur-Rehman, General Manager, Himalaya Mountain Valley Water (Pvt) Limited
Members of the Organizing Committee
Distinguished Guests, Ladies and Gentlemen!

Assalam-o-Alaikum!

It gives me a great pleasure to well come you all to this occasion and present my brief report on this workshop

In January / February 1994 we experienced spread of Hepatitis epidemic in parts of Islamabad which was later traced to be linked to the use of contaminated water. This may have happened due to a statistically possible human error or improper planning and management of the water supply system of the area There may have been many such incidents frequently occurring un-noticed in our beloved country elsewhere

In line with the recent trends locally bottled mineral water supplies are now available in the market being respectable and clean industry and no dearth of the raw material Yet one may have heard some one's whisper expressing his displeasure over the quality suspecting that some one might have bottled it from a source without proper treatment It has also come to our notice that a few foreign based agencies have expressed their disbelief on the quality of the locally manufactured bottled water

Under such situation, keeping in view the fact that our beloved land had been bestowed upon by The Almighty Allah the best quality water resources in the world, the scientific community represented by the CSP and PCRWR feeling it to be their National duty, joined hands to hold this workshop to achieve the following objectives

To create awareness amongst the masses for a quality water as a common responsibility

To bring the scientific community, govt agencies, organization such as the CDA and the manufacturing industry on a common plateform considering it a National requirement to improve upon the quality of drinking water

To create further interaction between the working scientists, theoretically strong scientists with academic and research responsibilities and the industry for collaborative R&D required to achieve the cherished goal

To label the available facilities which could be employed / approached to get quality analysis

To create scientific activities in collaboration with NGO's such as the chemical society, PCRWR, EPA, universities and the industry for regular intercomparison campaigns for analysis of drinking water samples Such activity would lead to certification of laboratories for quality analysis.

Apart from the inaugural and the concluding sessions the whole activity has been divided into three sessions technical session-I, commercial session and technical session-II In the technical session-I four invited lectures based on different aspects by experienced and knowledgeable scientists and professionals such as Dr. I. H Qureshi, Scientist Emeritus PINSTECH, Dr. S Riazuddin Professor and Director, Centre of Excellence in Molecular Biology, Punjab University Lahore, Dr Khurshid Ahmed,KRL Hospital, Islamabad and Dr M Jaffar, Quaid-i-Azam University, Islamabad will be presented This will be followed by commercial session where most of the invited papers belong to the industrial sector This has been done so intentionally in order to record meaningful participation of the industrial sector in such national and scientific activity and I am pleased to inform you that we have received enthusiastic response from the industrial sector so much so that we faced difficulty in arranging the allotted time to the speakers Keeping in view the importance of the occasion we have accommodated everybody However the time allotted has been decreased to only ten minutes to each and I would request to all speakers to strictly follow the timing and give maximum meaningful information to the audience In third session we have included two invited papers and the rests are scientific papers which the scientists and engineers would like to present and are basically concerned with the process or the analytical techniques required for quality analysis in one way or the other This will be followed by the concluding session which would include a brief report on the workshop proceedings, recommendations for the future and concluding address by the Chairman concluding session Dr. A Q. Ansari Chairman PCSIR Laboratories Islamabad

This occasion is being sponsored by three types of sponsors:

(a) Bottled mineral water manufacturers and I would like to mention their names as under:

(1) M/s Himalaya Mountain Valley (Pvt.). Limited,

(2) M/s Natura, Natural Mineral water, Islamabad;

(3) M/s Sparklette Continental Corporation, Limited, Islamabad, and

(4) M/s Northern Bottles (Pvt.) Limited, Islamabad.

(b) Manufacturer's of the filtered systems and here I would like to mention the following names

(1) M/s Service Industries, Lahore;

(2) M/s Arco International, Rawalpindi, and

(3) M/s So-Safe Water Purification Product, Islamabad

(c) Suppliers of Scientific Equipment and allied products required for quality analysis of water. I would like to mention the names as:

(1) M/s Faiz Enterprises, Islamabad;

(2) M/s We Brothers Scientific Works, Islamabad, and

(3) M/s H A Shah & Sons Islamabad.

We have been rather conservative in choosing the sponsors because of the reason that we only wanted competent companies to be associated with us at this first instance. I thank all for their cooperation and hope that this will be for our mutual benefits and service in the National interest.

Thank you all

WELCOME ADDRESS

Lt. Gen. (retd) Javed Ashraf Qazi
Secretary, Ministry of Science and Technology

Syeda Abida Hussain, Federal Minister for Science and Technology
Dr Bashir Ahmed Chandio, Chairman, Pakistan Council of Research in Water Resources
Prof. Roshan Ahmad, Chairperson, Workshop Organizing Committee
Mr Khalil-ur-Rehman of Water Industry
Distinguished Delegates, Ladies and Gentlemen!

Assalam-o-Alaikum!

It is indeed a pleasure for me to make this welcome address I am happy to see that our scientific organizations have become active and are now interacting with industrialists as well as with other members of scientific communities. This type of interaction, inter-discussion and barter of scientific and technological knowledge among the researchers, scientists, suppliers and consumers should result in development and prosperity for our country. Undoubtedly, water is the most essential constituent of life. A person can live without food for some time but not without water Life would be adversely affected if there were too little or too much water and would be miserable with polluted water.

The concept of pure water is a pre-historic necessity when methods of water purification were prescribed There are a number of verses in the Holy Quran and sayings of our Holy Prophet (Peace be Upon Him) about importance of clean water and its requirement for drinking, washing and body cleaning before prayers The flowing water without bad odour and changed colour used to be declared as clean However, new venues of impurities and pollution have now emerged which are to be resolved through scientific innovations. These contaminations and pollution are the after-maths of modern civilization, unchecked industrial growth and callous disregard for our environment made worse by rapid population growth. People living in deserts, villages, towns and big cities take the quality of drinking water at different standards Some may consider poor quality water fit for use because of its acceptable appearance, taste and odor, but it may not be true when analyzed on WHO standards. In contrast to that some one may consider only the deionized water fit for their health. Thus it is essential to educate the society about the actual requirement of the quality of drinking water and this is the main theme of this workshop.

The first step toward the establishment of standards to ensure the safety of water supplies is to agree upon some criteria for safety. It is well known that the water supplies of many of our large cities and towns are poor which is established by the fact that the large cities have, in recent years, suffered maximum incidence of waterborne infections and diseases Water has been identified as main diseases vector for dangerous diseases like Hepatitis. The risks of infections and diseases through drinking water are much higher in developing countries because lack of quality control measures and quality standards.

It is hoped that the latest developments on this subject will be presented and discussed in this workshop. A deeper understanding of the drinking water quality under present circumstances should result in evolving a suitable strategy for future water development and management programmes You have a limited time of five hours after the inaugural session, nevertheless, I would like to suggest that the workshop should focus on some of the key issues in its recommendations which may include the development of the water resources and its environmental protection, water scarcity and its impact on rapidly expanding urban populations; the devastating effects of water-borne diseases on human health, the involvement of people in managing their own water systems and research on new frontiers of water development and marketing. In this regard the adverse impacts of sub-standard water on infants and female population should not be forgotten

Madam Minister, Distinguished guests and participants, in the end I welcome you to this Workshop and I am grateful to you that you have spared your valuable time to be with us today. I am specially grateful to the managers of water industry for co-sponsoring this Workshop. Your presence at this forum indicates your interest and your views expressed candidly will lead to improvements in this vital sector.

Thank you.

ROLE OF INDUSTRY IN SAFE DRINKING WATER

Mr. Khalil-Ur-Rehman, General Manager
Himalaya Mountain Valley Water (Pvt.) Limited, Islamabad

Mohterma Syeda Abida Hussain, Federal Minister, Ministry of Science & Technology
Lt Gen (retd) Javed Ashraf Qazi, Secretary, Ministry of Science & Technology
Dr Bashir Ahmed Chandio, Chairman, Pakistan Council of Research in Water Resources
Professor Roshan Ahmad, Vice President, The Chemical Society of Pakistan
Distinguished Guests, Ladies and Gentlemen!

Assalam-o-Alaikum!

I feel greatly elated to welcome you on behalf of water industry of Pakistan to this well organized workshop on quality of drinking water One of the basic requirements for the development of science & technology is a mutual communication between the technical personnel's. Such a dialogue breach a new ideas and upto date scientific knowledge amongst the professionals Similar exchange at national level brings for an opportunity not only for a thought provoking review of the national technical problems but also ways of solving them through latest developments abroad

Ladies and gentlemen I am really grateful to PCRWR and CSP who have worked hard to provide a common platform to the scientists, industrialists and the consumer of the drinking water We can discuss the problems faced in bringing the quality of drinking water, gain knowledge and help each other to meet this national problem I am sure scientists will be dealing with the water sampling techniques, procedure, water quality testing for aesthetic, physical, chemical and micro- biological parameters alongwith the water quality standard and a legislation We the people from industry will be discussing our products, the source of water, method employed for its purification, plant processing and use of different types of filters The delegates from M/s Ava, M/s Nautra and M/s Sparkletts are here who are in the water field I hope we will be benefiting from them As far as Himaliya Mountain Valley Water Pvt Limited is concerned we are serving for the last three years

I would like to give a brief introduction of our company The plant is situated in Abbottabad and our source of water is Himalaya Mountain Valley Spring Water which is further processed, filled and marketed We have state of the art machinery imported from America and Italy which includes bottling plant from M/s Uniloy of America capable of making 2800 PET bottles per hour. Two water purifying capsules and multi media filters from M/s Aqua of San Jose, California, which are filled with improted silica sand, Charcoal and gravel, then we have processing plant from Italy consisting of rinser, filler, capper and labeler with a capacity of filling 4500 bottles per hour Our filled bottle is touched by a human hand only when it comes out of the labeling machine and remains untouched by human hand throughout the filling process.

For disinfection of water we have imported an ozone generator also from America which ozonizes the water during the filling process for disinfection. We have engaged professional chemists who remain busy in our well equipped lab. To keep strict check on the quality of water and under no circumstances compromise on quality We send our water samples for periodical analysis to Fresenius institute and Alteapotheke of Germany and in Pakistan to PCSIR, Shifa International, CMH, Agha Khan University Hospital and Qualitest Laboratory Karachi.

As far as our distribution is concerned we have a complete network of distributors all over Pakistan who are responsible for distribution of our product. While our institutional sales are looked after by our company itself through our two offices in Islamabad and Karachi

Ladies and gentlemen, I hope the scientific exchange during this one day workshop on quality of drinking water will result in achieving our objectives of coordinated efforts for this National issue. I wish all the best. Thanking you very much

Khuda Hafiz, Pakistan Paindabad!

KEY NOTE ADDRESS

Dr Bashir Ahmed Chandio
Chairman, Pakistan Council of Research in Water Resources, Islamabad

Syeda Abida Hussain, Federal Minister for Science & Technology
Lt. General (retd) Javed Ashraf Qazi, Secretary, Ministry of Science & Technology
Prof Roshan Ahmad, Chairperson Workshop Organizing Committee
Mr Khalil-ur-Rehman, of Water Industry
Distinguished Delegates, Guests, Ladies and Gentlemen!

Assalam-o-Alaikum!

It is indeed an honour for me to present my semi-technical paper before the distinguished audience I feel pleasure to say that the Pakistan Council of Research in Water Resources (PCRWR) and Chemical Society of Pakistan (CSP) are pioneers in organizing National Workshop on Quality of Drinking Water in Pakistan Previously, the Scientists, Engineers, Industrialists and Professionals dealing this subject were encircled with their research and development activities in isolations In order to break this isolation and bashfulness, CSP and the PCRWR have joined hands and have provided a common platform for personnels and firms to exhibit as well as introduce their latest technologies and recent research findings

The water we use for domestic purposes is being polluted from different sources. The one that is being conveyed through pipe lines is polluted because of defective joints and damaged conduits, and the one routed through open system is contaminated by chemicals of municipal and industrial wastes, and pesticides and insecticides of agricultural fields. Due to these and many other contaminations, the drinking water is becoming unsafe to consume The polluted water has turned up as one of the leading health challenges in the world today because it is creating diseases, creating physical and mental disorders, causing cancer and many others attacking intestine, stomach, liver and kidneys

According to recent WHO estimates 27% of the world population lives without a clean and safe supply of water. The case of Pakistan may even be put at low ebb of sanitation and safe water supply standards, though in population it is the 9th most populous country in the world In Karachi and other major cities, more than 80% of the population has no access to clean potable water. Only in Karachi 60% of all hospital admissions are due to water-borne diseases It has been estimated that some 57% of the total deaths in Pakistan are caused due to use of contaminated water while figures have gone upto 60 percent for children It has been estimated that in this country some 10,000 persons die every year due to kidney-related diseases caused by drinking of dirty water Infant morbidity is so serious that more than 100 infants die every day because of polluted water

Unfortunately both the public as well as private sectors are polluting water bodies at one or another pretext or disguise If 90% of the industrial establishments does not have water treatment plants and are disposing their effluent directly or indirectly into the rivers and lakes, the case of public sector like WAPDA also cannot be quoted as satisfactory Most of the SCARPs are discharging their contaminated field drainage effluent into fresh water bodies, so that not only the salinity and pollution of the Indus river water rises but also it becomes more and more toxic as it travels southward

In order to make the system self sustained, the water managers have to levy water charges according to volume consumed. However, willingness to pay for improvements in drinking water quality only increases with increase in income and level of education Thus public understanding of water quality is must. It is believed that source protection remains the most reliable and low-cost method currently available to protect drinking water quality Many decision makers consider that instead of spending huge resources to control water borne diseases, one should focus on prevention methods and that with the use of clean and pure water, country can prevent water-borne diseases to a greater extent though debate is open about fixing the standards for both microbiological and chemical parameters. As the demand for clean drinking water has increased, the industrial communities have also diverting their resources on marketing of drinking water.

The Government of Pakistan is very much alive to shortage of safe drinking water. It has set fourteen national conservation strategies and priorities under the development programme of 2010 namely.

- protecting water bodies and sustaining fisheries,
- increasing irrigation efficiency,
- protecting watersheds,
- conservation of croplands,
- supporting forestry and plantation,
- restoring rangelands and improving livestock;
- conserving biodiversity;
- increasing energy efficiency;

- developing renewable resources,
- preventing and combating pollution;
- managing urban wastes;
- supporting institutions for common resources,
- integrating population and environment programmes; and
- preserving the cultural heritage.

The mother nature has ensured unpolluted supply of water through hydrologic cycle but man made interventions, human greed and unscientific management have tended to pollute this supply line For example, disposal of untreated industrial and municipal wastes is introducing dangerously high levels of toxic pollutants into our rivers, reservoirs, lakes In Kasur 109 tanneries are poisoning the groundwater. In Lahore, more than 10 million gallons comprised of raw sewage, industrial wastes and the run-off from chemicals, fertilizer and pesticide units are dumped into the Ravi River every hour. The 94% untreated water in Karachi is discharged into the Lyari and Malir rivers which causes deoxidation, kills the aquatic life and generates unpleasant odours.

A study conducted by the Health Services Department of the KMC shows that out of 372 samples of drinking water 340 were found unfit for human consumption as E-coli bacteria were detected This finding indicates that sewage water was being mixed with the drinking water supply system Reports prepared by organizations other than the KMC have also indicated the presence of pathogens and turbidity in Karachi's drinking water. The situation of twin cities of Islamabad and Rawalpindi is also not too different because about 40% population is using poor quality drinking water As a result of this uncontrolled and unmonitored disposal of wastes, into water bodies, the principal sources of drinking water are progressively getting polluted.

Groundwater is a main source of drinking water supply all over the world The fresh water aquifers are being treated as good sources of quality water They are prone to salt water intrusion and upconing but were always taken unaccessible to chemical and pathogenic contaminations that case no more exists The analysis of groundwater from wells, tubewells and hand pumps shows that it is invariably polluted and is unfit for human consumption In developed countries, groundwater management is thought by the user groups to be better than its treatment, and local and state level involvement is favoured over federal intervention.

All my this discussion is as a matter of fact aimed at knelling bells of danger that our water resources are being polluted at such an alarming rate that we are left with little time to waste The contamination of our water sources and resources from nuclear and other lethal wastes is yet to be determined. It is therefore very important that the water quality all over Pakistan is monitored by an umbrella federal organizations regularly. I can quote the example of Malaysia where the need for the development of a national program for surveillance of drinking water quality was identified in 1983 because it was presumed that the quality of raw water sources would deteriorate further with increasing urbanization and development. Hence the national drinking water quality surveillance programme was launched to bring together various departments and agencies related to the provision of drinking water in a cooperative effort without the need to enforce any laws or regulations This programme is reported very successful The PCRWR has made its modest efforts to create awareness and to help supply good quality drinking water in the country For example.

(i) Research based rainwater harvesting techniques are practiced in the Cholistan desert where basically rain water is collected for rangeland management but two of our water storage ponds have been dedicated for local consumption where house wives of Dingarh village are taking this water for their drinking and domestic needs;

(ii) Electrical Resistivity Survey and Electrical Well Loggings are being conducted in various parts of the country to select the suitable sites for installation of tubewells to get good quality groundwater; and

(iii) A well equipped water quality laboratory has been established in Islamabad to analyze forty different parameters of drinking water required for reliable drinking water quality analysis

Before concluding I would like to say that drinking water will be equivalent to oil in the next millennium The GOP should make its generous investment in the research based development and management of water resources The honourable Minister may kindly consider to involve professional research and monitoring organizations to ensure that new projects in water sector are conforming with environmental standards and that they are scientifically sound and economically viable.

My sincere thanks are to Syeda Abida Hussain, who has honoured my request and has spared her valuable time to inaugurate this session. General Qazi, I feel privileged to work with you, I really enjoy your moral as well as financial support.

I am also thankful to Dr Din Muhammad, Dr Roshan and other organizers of Chemical Society who reposed their confidence in the PCRWR and brought the concept of collaborative work My thanks are to the organizers and sponsors of this workshop, I sincerely appreciate the efforts of my team who has made its untiring effort to make this workshop a successful event Dr Abdullah and Mr Aslam Tahir are the key figures of my team who really matter to me at this moment.

Distinguished participants, ladies and gentlemen, the overall success of this workshop, lies in your active participation.

Thank you.

INAUGURAL ADDRESS

Syeda Abida Hussain
Federal Minister for Science and Technology, Government of Pakistan

Lt General (retd) Javed Ashraf Qazi, Secretary, Ministry of Science & Technology
Dr Bashir A Chandio, Chairman, Pakistan Council of Research in Water Resources
Prof. Roshan Ahmad, Chairperson, Workshop Organizing Committee
Mr. Khalil-ur-Rehman of Water Industry
Distinguished Delegates, Ladies and Gentlemen!

Assalam-o-Alaikum!

The objectives of developing country mostly rotate around better health, basic education, shelter, ensured supply of food items in the market, clean environment and safe drinking water It is also very well known that human health and survival depend on use of uncontaminated and clean water for drinking and other domestic purposes As the population is increasing the world over, the demand for water also increases. Should this august audience ponder upon these factors?, its members would find that neither any item would be complete without water nor prosperity and development of the nation in their true sense would take place without availability of clean water.

As the onset of my inaugural address you genuinely should expect that I would say few words in admiration of your this collaborative effort So I do! I commend this effort. But as you know my background that I represent poor classes of rural and agrarian communities I find little in this workshop for them I would like to stand corrected rather would be pleased if the organization committee were to tell me that its today's effort also focuses on the uncontaminated supply of potable water to the 60% of the poor population that is living in rural areas I think similar is the case with slum areas of urban population.

Most of the rural population use to take its drinking water from open wells or handpumps but now the salinization of the groundwater as well as its contamination from agricultural wastes is polluting this source. At many places, the bad odor like that of hydrogen sulphide and salty smell is quite detectable As a result this population has been complaining about spasmatical stomach pains and other gastric dis-orders

I also draw your attention to the people who are living in deserts like Cholistan, Thar and Thall, and the hilly and sub-hilly tracts of Sindh and Balochistan where people live on rainwater stored in open ponds which is a common property for all living beings which is being infested by all pathogens. It is a worst type of slavery of present times that women travel miles to bring one or two clay pitchers filled with water on their heads. I think it will be a great service to Pakistan if you scientists and industrialists come up with a viable solution to redeem ill consequences of our neglect and bad planning

In the agrarian community as that of ours, water is also recognized a key factor for poverty alleviation I also believe that same is the case for the industrial society of today. It is my common observation that un-guaranteed supply of water for domestic purposes has forced the consumers to construct their underground water tanks and suction pumps to draw the water directly from supply line and store it in their underground tanks. So those who don't have this facility would be usurped of their share I think that such type of forced withdrawal of drinking water may also tend sewage water which is running parallel to drinking water system, to enter into drinking water lines. My intuition also cautions me that such type of domestic underground or even overhead tanks neither would be properly constructed nor adequately maintained.

I would not feel any hesitation to say about house wives who are more vulnerable than men to the environmental contaminants I strongly suggest that this workshop should recognize the role of feminine gender and ponder upon the ways and means as how to bring ease and comfort to this sector in the same way or even better than male society ordain for themselves. All over the world, women play a crucial role in environmental management. Every one present here should be aware of the fact that in rural areas, women are the main collectors and users of water for their households activities They can be immediately affected by degraded water systems Unfortunately being netted in the low income group, rural communities cannot relish the delicacies of bottled water, hence this forum may have more emphasis as how to meet the basic needs of drinking water for rural areas.

I am glad that the Pakistan Council of Research in Water Resources and the Chemicals Society of Pakistan have jointly organized this national workshop on Quality of Drinking Water where water related industries are also collaborating with the organizers to make this workshop a success. I hope the deliberations of the workshop will throw more light on the important areas on the use of good quality drinking water, control of water borne diseases and supply of low cost bottled water at public places. I suggest that deliberations should develop new strategies providing good quality water to every user. The Ministry of Science and Technology has invested a moderate amount of money on setting up of a well equipped water quality laboratory in PCRWR at Islamabad. I suggest that this forum should look into the capabilities of the laboratory and judge themselves as whether or not it can be of a good use to you I thank the PCRWR, CSP and Water Industry for their collaboration in this workshop and highly appreciate the participation of scientists, engineers and industrialists, whose contributions, I am sure, would be highly valuable.

I would keenly look forward to receiving the recommendations of this workshop Of course, a follow-up of the recommendations is necessary in order to assure the implementation of the recommendations. I would however suggest that they may be few and attainable If they are convincing, and I am positive that your forum is capable of doing so, I will be very happy to get you every support from my government. You may like to consider

(a) How masses should be able to purify their water at a bearable price;

(b) How supply of potable water is made self sustained,

(c) How drudgeries of feminine class is removed;

(d) How quality of water resources is preserved, and

(e) What public sector involvement is required.

With these remarks, I feel great pleasure in inaugurating the workshop and I wish you allsuccess in your deliberations

VOTE OF THANKS

Professor Roshan Ahmad
Chairperson, Workshop Organizing Committee

Syeda Abida Hussain, Federal Minister for Science & Technology
Lt Gen. (retd) Javed Ashraf Qazi, Secretary, Ministry of Science & Technology
Dr. Bashir Ahmed Chandio, Chairman, Pakistan Council of Research in Water Resources
Dr. Din Mohammad, The Organizing Secretary
Mr. Khalil-ur-Rehman, General Manager, Himalaya Mountain Valley Water (Pvt.) Limited
Members of the Organizing Committee
Distinguished Guests, Ladies and Gentlemen!

Assalam-o-Alaikum

Since a long time the Chemical Society of Pakistan has been planning to organize some type of workshop, seminar or symposium in which we could bring the chemists working in the universities, R&D organizations and the industrialists on one platform so that different problems of mutual interest could be discussed and solved. Some how we were unable to organize a general workshop on the subject of chemists - industrialists interaction . Thanks to Pakistan Council of Water Resources and some people from industry for collaborating in organizing this workshop which is just an initial step to proceed towards a goal.

The need for organizing this workshop and the objectives have been summarized in the workshop brief I hope that the deliberations of this workshop will throw some light on important measures to be taken to improve the quality of drinking water for use of the general public We are really thankful to madam Syeda Abida Hussain who has spared some of her valuable time to grace this occasion and inaugurate the workshop. Our sincere thanks are also due to Lt. Gen (retd) Javed Ashraf Qazi for his presence on this occasion and delivering the Wellcome address. On behalf of the Chemical Society of Pakistan I extend my gratitude to Dr. Bashir Ahmed Chandio for collaborating with us in organizing this workshop. We are grateful to the representatives of industries for participating and co-sponsoring the workshop My special thanks are due to Mr Khalil-Ur-Rehman, General Manager Himalaya Mountain Valley Water Ltd. and Mr Akram Chaughtai Service Industries Ltd. for being the major sponsors. The members of the organizing committee deserve my special thanks for working hard to make this workshop a success. I must acknowledge the sincere efforts of Dr. Din Mohammad, Dr A. H. Rehan, Dr. M. Abdullah, Mr Aslam Tahir and their co-workers who have worked day and night for this workshop. My thanks are also due to all other organizations who have sponsored this workshop and finally the distinguished participants, ladies and gentlemen thank you very much for your participation.

TECHNICAL PAPERS

DRINKING WATER QUALITY AND STANDARDIZATION IN PAKISTAN

Bashir A. Chandio, M. Abdullah and M.A. Tahir
Pakistan Council of Research in Water Resources, Islamabad

ABSTRACT: Drinking water in Pakistan is required for about 136 million population out of which 68% is living in rural areas Though most of the drinking water supplies are drawn from surface water and groundwater, yet harvested rain water also makes some contribution in sandy deserts and hilly areas However, if the annual growth rate remains to be 2 7% then it would be very difficult to enhance the safe water coverage to the masses within next 10 years

Presently, the water quality is a more serious problem in this country than its volume because only about 40% of the total population is receiving potable water according to World Health Organization (WHO) standards The main quality problems related to drinking water have emanated from turbidity, inadequate sanitation, high bacterial load, unhygienic water storage, discharge of civil and industrial effluents into water bodies, and infiltration of toxic leachates from agricultural fields The PCRWR has made water quality sampling from surface and groundwater sources around Islamabad & Rawalpindi and has observed that most of the drinking water samples of the area are contaminated with bacterial load, while a few have high concentration of turbidity, nitrate nitrogen, sodium, iron and lead A number of preventive and corrective measures to standardize and purify the drinking water are therefore discussed in this paper

Introduction

Water is an absolute necessity as well as a universal solvent. It contains dissolved materials and suspended particles even in its natural state. Though agriculture is its main consumer, other sectors are also competing and have potentials to pay more For domestic purposes, it is required between 150 and 300 l/day-capita in which groundwater makes more contribution because in principle it is clean and biologically uncontaminated, 70% of drinking water supply comes from aquifers. Presently clean drinking water supplies are required for an estimated population of about 136 millions, out of which 68% is living in rural areas.

Whereas surface water pollution comes from pathogens, chemicals, and untreated wastes; shallow aquifer pollution comes from infiltration of waste disposal, agro-chemicals, and other natural pollutants. The pollution problems and environmental concerns necessitate that all types of wastes should be treated before they are disposed, however, implementation of such programs in developing countries is hindered by cost, availability of resources, and the level of expertise required to operate the programs.

The experts believe that the water quality is a more serious problem in this country than its quantity because only about 40% of the total population is receiving potable water according to World Health Organization (WHO) standards The main quality problems related to drinking water have emanated from turbidity, inadequate sanitation, high bacterial load, unhygienic water storage practices, discharge of civil and industrial effluents into water bodies, and infiltration of toxic leachates from agricultural fields into aquifers. Future deterioration of water quality in developing countries should be a consequence of increased industrial production, rapid increase in water use, deforestation, and the destruction of natural filter systems such as wetlands.

The increase in water demand proportionate to population growth is common every where. But better financial position and judicious resource allocation made by the developed countries have offset the consequences of population pressure on available water resources. They have controlled the population growth rate, have developed new resources and have managed the available resources prudently. To meet with the increased population pressure of the city of Berlin on the water resources, an integrated management approach for water resources was planned through advanced treatment of available resources to meet the stringent quality requirements and to shift the treatment towards the sources of pollution to obtain an optimum water resource protection. The low income countries however adopt some relaxation. For example, in Morocco, maximum acceptable level for the total dissolved solids has been raised from 1500 to 2000 mg/l

The presence of organic and inorganic compounds beyond threshold limit causes health problems Therefore water quality should be maintained against diverse groups of organic chlorinated compounds, chlorophenols and polychlorinated biphenyls, fluorides, pH, chlorides, total hardness, specific conductivity and sulfates. Many public water supplies also contain chemicals that cause cancer It is necessary to detect the carcinogenic material level in the water for prevention purposes Nonetheless it should be kept in mind that a total absence of carcinogens in water is unrealistic. Regulating water quality with respect to carcinogens requires an assessment of the risks of exposure. Some so called qualities of drinking water seem to be related to increased gastric cancer incidence. They are soft water (poorly mineralized, low in magnesium, and sometimes containing radioactive substances) and the presence of nitrogen compounds (ammonia, nitrates, nitrites, nitrosamines). Hard, highly mineralized water is associated with lower cancer rates. One study associated high lead levels in water with cancers of the stomach, kidney, and intestine and leukemia

It is very difficult to provide water for any consumer at 100% uncontaminated form because of inhibitively high cost of such type of treatment and purification. Economics plays an influential role in the final decision by a community with respect to the selection of their drinking water treatment process. Fortunately, for most toxic effects there is a threshold level below which no harm occurs even over a lifetime of exposure. It is further observed that modernization of water sources alone is not a sufficient measure for the improvement in clean water supplies. As users have a strong influence on the quality of their drinking water, their education and that of dwellers regarding management of their sources is considered as next important factor to help improve the supply of clean water

The quality enforcement efforts have in general improved the performance of public and private facilities that obtain their drinking water from lakes, rivers and streams, treat it and distribute it to their customers Martapura River of Indonesia was contaminated with total coliform, Escherichia coli, and hydrogen sulfide but when that water was treated and chlorinated in a residual of 1 0 mg/L before it was distributed to the city, no coliform or hydrogen sulfide producing bacteria were detected.

The distribution system itself can contribute to this deterioration. Numerous examples of waterborne outbreaks have demonstrated the importance of the distribution system in preventing disease The media, environmental groups and consumers therefore want to see tap water coming from those sources that are not polluted. The water industry, on the other hand, continues to reassure the public that drinking water remains as good as it was 50 years ago.

Ground water is rather a main source of drinking water because of its presumable uncontaminatable situation. However, the analyses in the country like USA have showed a relatively high concentrations of dissolved lead, copper, iron, and zinc and trace amounts of a few organic compounds In Pakistan, the potable groundwater is being drawn through tube-wells, hand pumps, open wells, springs and karezes. However, where the groundwater is brackish or not easily available, the surface water is diverted to filtration plants where it is allowed to remain stagnant for a specific period to achieve partial settling of suspended materials, then filtered, whereas in deserts or areas outside Indus basin, harvested rainwater is used for drinking purposes

National Development Plans

Till the year 1980, only 33% of the total population of Pakistan had the access to the acceptable drinking water. Hence the International Drinking Water Supply and Sanitation Decade was launched in 1980 to provide potable water to all urban population and 66% of rural population. The priorities and targets of the decade were included in the 6th Five Year Plan. At the end of 7th Five Year Plan of the Government of Pakistan the proposed coverage of safe water supplies was extended to 75% of population, however, the above targets were not fully achieved, so that by the year 1993, only 61 5% of the total country's population had access to safe drinking water. Subsequently, the 8th Five Year Plan envisaged to provide drinking water facilities to 95% of population. It is envisaged that in the next 10 years it would be very difficult to enhance the safe water coverage for the population which is increasing at a rate of 2.7%.

Allocation of funds to the water supply sector as well as to other sectors would always remain short because of economical constraints and very high population growth rate. Nonetheless planners and decision makers would genuinely worry as how to extend drinking water facilities to additional 3.5 million per year It is feared that with this much growth rate our constrained economy may not be able to bear the consequent financial and administrative responsibilities unless they are shared or completely off loaded by the private sector. A change in the present policy is strongly required, which might rotate around economics with a prime concern as how to provide safe drinking water facilities to all consumers under a self sustained system

Drinking Water Quality Assessment and Impacts

The quality of surface and groundwater being used for drinking by urban as well as rural population is 'poor'. It has been assessed that more than 40% end users are not receiving potable water as per WHO recommendations. The analysis of water samples collected from Islamabad and Rawalpindi by PCRWR have shown the similar results (Tables-5 & 6). Water quality survey of Karachi and Lahore have revealed that majority of water samples contained high bacterial load and sewage organisms.

Almost 95% of the wells of the Karachi city and its suburbs were highly polluted both bacteriologically and chemically; the tested samples possessed contain high concentration of total dissolved salts as a result of sea water intrusion into fresh water aquifers in the coastal areas. Whereas the quality of groundwater in Lahore is marginally permissible, water samples collected from the adjacent localities of Lahore found to be unfit for human consumption. Similar situation was observed for the rural areas of NWFP, while the situation in Balochistan was worst.

The World Health Organization estimates that 500 million diarrheal episodes occur each year in children under five years in Asia, Africa and Latin America. The extent of enteric diseases in different areas depends upon the extent to which a drinking water is exposed to contamination. Many incidence of typhoid, dysentery, hepatitis and other enteric and respirator infections in many countries have been reportedly transmitted through water The entry of these water carried human diseases into water bodies is to be prevented by proper water treatment and enforcing quality standards.

In addition to above, there are many other diseases related to ingestion of toxic substances like mercury, chromium, lead, zinc, cadmium, nickel, sulphide, chlorine, ammonia, cyanide, and organic chemicals. The substances present in different industrial effluents in Karachi, and other cities alongwith their levels and maximum limit are briefly as given in Tabl-1.

Table 1: *Water Pollution Level in Karachi*

Substances	Levels in Industrial Effluent (mg/l)	Max. Limit (mg/l)
Chromium (Cr)	200	0 5
Lead (Pb)	12	0 3
Mercury (Hg)	-	0 004
Zinc (Zn)	1000	5
Copper (Cu)	20	0 5
Nickel (Ni)	1 2	0 3
Cadmium (Cd)	-	0 03
Cyanide (CN)	-	0 15
Phenols	-	1 0
Iron (Fe)	20	4 0
Oil & Grease	30	5

It can be seen that contents of heavy metals are alarmingly high Their presence is very logical because textile, tanneries, and other industries established in Karachi are disposing their effluents containing above heavy metals without treatment These effluents either dumped into Liyari and Malir River or are pounded where from they are leached down and are mixed up with groundwater There are also evidences that enroute to their disposals, the effluents mix up with drinking water through leaky and damaged water supply lines. As a result of this contamination the people of Karachi are suffering from various diseases These effluents ultimately find their way in the sea where marine life is affected adversely.

It is estimated that 30 percent of all reported cases of illness and 40 percent of all deaths in Pakistan are attributed to water diseases Recently when survey conducted by PCRWR showed that 81996 cases of water related diseases were registered only in Basic Health Units of Rawalpindi Division within a year.

Status of Water Treatment

In the areas where groundwater is potable, it is being utilized directly. In semi-hilly and desert areas, rain water is harvested and used after simple cloth filtration process. In mountainous areas, springs are mainly adopted as source of supply which is generally good in quality

In the areas where groundwater is brackish or deep, surface water is invariably used for drinking purposes after passing through slow sand filters to remove suspended solid materials. This filtered water is then chlorinated in treatment plants to reduce the suspended and bacterial loads and is then pumped to various consumers in the urban areas like Karachi, Faisalabad, Rawalpindi and Islamabad In these treatment plants, Alum is being used as a coagulating agent. Then chemically mixed water is conveyed to a flocculation chamber until a thick floc of settleable matter is formed which is removed in sedimentation basins The clear water is finally filtered through rapid sand filter beds and in most cases post chlorination is practiced. Despite the excellent facilities for chlorination and treatment available in major cities, it has been observed that the drinking water, finally supplied to users, is yet not "Safe" for drinking

Water Quality Standardization

The standards for drinking water quality are always based on scientific research and epidemiological findings and as such provide guidance for making risk management decisions related to the protection of public health and the preservation of the environment. Water quality standards are legal impositions enacted by means of laws, regulations or technical procedures, which are established by countries by adapting guidelines to their national priorities and taking in account their technical, economical, social, cultural and political characteristics and constraints

Water intended for human consumption must be free from harmful quantities of microbial organisms and chemical substances which may pose a hazard to health. Supply of drinking water should not only be safe and free from dangers to health but also be aesthetically acceptable. The purpose of setting standards is to define the quality of water that is safe as well as palatable for human consumption.

Pakistan Council of Research in Water Resources had prepared a draft act on safe drinking water including standards in 1993 for Pakistan and forwarded to Ministry of Science and Technology for further process The standards contained in the act were basically based on WHO water quality guidelines but were further modified according to financial, environmental and technical conditions. These standards were prepared in consultation with water quality experts of different relevant departments like PPH, Planning Commission, PCSIR etc. The proposed water quality standards are presented in Tables 2 to 4

Table 2 *Bacteriological Standards*

Organisms	Guideline Value
a All water intended for drinking E coli or thermotolerant coliform bacteria	Must not be detectable in any 100-ml sample
b Treated water entering the distribution system E coli or thermotolerant coliform bacteria Total coliform bacteria	Must not be detectable in any 100-ml sample Must not be detectable in any 100-ml sample
c Treated water in the distribution system E coli or thermotolerant coliform bacteria Total coliform bacteria	Must not be detectable in any 100-ml sample In the case of large supplies, where sufficient samples are examined Must not be present in 95% of samples taken throughout any 12 month period

***E coli is the ore precise indicator of fecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. Turbidity should be <1 NTU: For disinfection. with chlorine. pH preferably <8.0 and residual free chlorine should be 0 2-0 5 mg/l with minimum 30 minutes contact time.**

Table 3. *Standards for Inorganic Health-related Constituents (These standards apply to water supplies)*

Constituent	Unit	Highest Desirable Level	Maximum Permissible Level	Toxic Effects
Lead	mg/l	0 05	0 05	Children particularly susceptible to effects of lead on central nervous system
Mercury	mg/l	0 001	0 001	Neurological effects
Fluoride	mg/l	1 0	1 5	Dental fluorosis in children, excessive concentrative may cause crippling skeletal fluorosis
Nitrate (NO_3)	mg/l	45	45	Infantile methemoglobinemia

Table 4: *Standards for Aesthetic and other Inorganic Health Related Constituents*

Constituents	Unit	Highest Desirable Level	Maximum Permissible Level	Undesirable Effects
Turbidity	NTU	2 5	5	Unaesthetic decrease in efficiency of disinfection
Colour	Pt, Co	5	15	Unaesthetic
Taste and Odour	-	Unobjec	Unobjec	Taste and Odour
TDS	mg/l	500	1500	Salty taste, corrosion or instruction
Iron	mg/l	0 1	1 0	Taste, discoloration
Manganese	mg/l	0 05	0 5	Taste, discoloration
Magnesium	mg/l	30	150	Stomach disturbances
Copper	mg/l	- 05	1 5	Taste, corrosion of pipe & utensil taste
Zinc	mg/l	5	15 0	Taste
Sulfate	mg/l	200	400	Corrosion, laxative effect
Chloride	mg/l	200	600	Taste, corrosion
pH	-	7 0-8 5	6 5-9 2	Taste, corrosion
Hardness	mg/l	200	500	Corrosion or scale formation
Phenolic sub	Mg/l	0 001	0 002	Taste

Table 5: *Pollution Problems in the Water Supply System of Islamabad*

Sr No.	Year	Pollutants	Highest Desirable Level (WHO)	Above the Acceptable Level (%age)	Health Effects
1	1989	(NO_3-N)	10 mg/l	5 66	Disturbances in stomach and intestine, formation of methaemolobinaemia may cause death
2	1989	Bacterial	NIL	66 03	Cholera, typhoid, gastro enteritis etc
3	1997	Bacterial	NIL	33	Cholera, typhoid, gastro enteritis etc

Table 6: *Drinking Water Quality Profile (Exceeding WHO Standards) Rawalpindi District (1994)*

S No	Parameters	WHO Guide-lines	Percentage of Samples Exceeding WHO Guidelines					Health Effects
	Tehsils		Gujar Khan	Kahuta	Murree	Rawalpindi	Taxila	
	No of Samples		29	19	23	19	26	
1	Bacterial Indicator -E Coli -Coliform -Non Coli	Nil Nil Nil	65 5 86 2 86 2	84 2 78 9 89 5	73 9 87 87	68 4 89 5 89 5	53 8 76 9 73 1	Diarrhea, Dysentery, Stomach & Intestinal disturbances etc)
2	Nitrate (N)	10	24 1	26 3	-	-	11 5	Infantile methaemoglo-binaemia, Gastrointes-tinal disturbances
3	Iron	0 3	-	-	34 8	-	-	Hemochroma-tosis
4	Sodium	200	17 2	-	-	10 5	-	Vomiting, Muscular twitching, Hypertension
5	Manganese	0 1	86 2	63 2	26 1	10 5	100	No adverse health effects in humans were found Undesirable taste, Incrustation Problem

Recommendations

In order to ensure the supply of quality water to entire population following recommendations are suggested

1 An umbrella water quality monitoring and evaluation cell should be established in the center with its provincial branches,
2 to establish water quality standards for all sectors like bottling water quality;
3 to select and recommend appropriate technologies for design, construction, operation and maintenance of drinking water supply systems,
4 to arrange training programmes on water quality, and its standards;
5 to embark on awareness programmes about water quality, pollution and sanitation on Radio, TV and Newspapers; and
6 to ensure implementation of drinking water quality standards all over Pakistan.

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ENVIRONMENTAL POLLUTION AND CARCINOGENESIS

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ABSTRACT: The quality of life at both the social and individual levels would be severely restricted if we had to live without petroleum products, plastics, synthetic textiles, man-made mineral fibers, antibiotics and synthetic drugs or without the synthetic materials needed to produce modern electronic devices In many ways chemicals are a basic factor in the well being and effective functioning of present day societies They may play the role of being essential in one way and responsible for deleterious effects under other conditions depending upon the nature and amount present Their effects in terms of environmental pollution especially related to the quality of drinking water are briefly discussed in this paper

Introduction

As in the case of drugs, the use of new chemicals implies not only the desired benefits but also adverse effects We are compelled to compromise between costs and benefits When the desired and the adverse effects of the use of chemicals are weighed, it is pertinent to ask whether we really need all the new chemicals that are synthesized annually and whether all the 60,000-70,000 chemicals used daily in industrialized societies are truly essential. Some people have wondered how long our ecosystem can survive and how long the bio-system, man included, can tolerate the doubling of the consumption of chemicals that occurs every 7-10 years

In fact, all nations within the United Nations family are faced today with growing problems of 'chemicalization', and questions of weighing risks and benefits have become more and more relevant. This is because all societies have become increasingly dependent on chemicals Severe damage to the ecosystem has been recognized, such as damage due to acid rains, the pollution of solid and water and the increasing rates of certain types of cancer and allergies. Severe chemical accidents or epidemics, such as the poly-chlorinated biphenyls (PCBs) epidemics in Japan, Taiwan and the USA, the dioxin accident in Italy, the mercury epidemics in Iraq and Japan and the food-oil epidemic in Spain, have also emphasized the importance of chemical safety even in highly developed societies[1]

In most European Countries, presently, 45% of the labour force is exposed occupationally to chemicals during various stages of production, packing and transport and the specific use of chemicals or in the handing of chemical wastes On average some 3.5% of the labour force is exposed to carcinogens, but in the small industries 22% of the workers face the possibility of exposure to carcinogens and some 46% to allergens We are still surrounded by facilities and apparatus containing PCBs. There are more than three million pieces of electrical apparatus containing more than 2000 tonnes of PCBs in a small country like Pakistan (General Statistics)

Long ago, scientific communities warned about the global pollution of the ecosystem, including man 'Chemicalization' entails problems that were not perceived by decision-makers when early warnings were issued, now these problems are appearing in concrete form before the administrators, and effective solutions are urgently needed. To a great extent the problems are international in character and, consequently, the solutions require international action and collaboration.

Extent of Pollution

Several governments and political and economic associations including the European Economic Community, the Council of Mutual Economic Assistance and the Organization for Economic Cooperation and Development (OECD), and international organizations within the United Nations, have undertaken specific programmes to meet the problems caused by chemicals All the international and national actions undertaken thus to demonstrate the need for governments to regulate the growing use of 'chemicals' in both developed and developing countries Furthermore, an increasing number of international conventions and agreements have been compiled to prevent transboundary effects of chemicals. Joint action for the monitoring of the exposure of both the ecosystem and the population always plays an important role in these programmes and agreements

Several means can be applied to prevent chemical hazards The most effective one would be to refrain from using hazardous substances and to replace them with non-hazardous ones Not all hazardous exposures, however, can be avoided, because we simply do not know all the possible risks, despite extensive testing programmes. So far, appropriate toxicity testing has been done only for about 10-25% of the chemicals used daily[2]

Chlorination of water, presumably to kill its microbial content, exposes the consumer to a variety of hazardous compounds. The variables of established importance in the production of potentially toxic compounds are total organic carbon, pH, ammonium and bromide ion concentration and the qualitative composition of the organic matter. The presence of the said impurities relate to the production of Trihalomethanes such as chloroform, bromodichloromethane, chlorodibromo-methane etc.[3]

Inorganic elements such as Arsenic, Brelium, Cadmium, Chromium, Nickle, Lead, Selenium and Zinc interact very strongly even at trace levels, both with other trace elements and with substances commonly present in the environment Some of these interactions have been found to be very complex in their relevance to carcinogenesis Several of the elements have been shown both to enhance and to inhibit experimental carcinogenesis for tumor growth, depending on the type of tumor, tissue or carcinogenic agent administered DNA fidelity assays of 40 metal compounds, indicate that cations of Hg, Be, Cd, Co, Cr, Cu, Mn, Ni and Pb increase incorporation of nucleotide bases in the daughter strand of DNA that is synthesized in vitro from polynucleotide templates by microbial DNA polymerases. It has been confirmed that carcinogenic metal cations cause notable increases in the mis-incorporation of all four nucleotides by DNA polymerases in vitro, whereas non-carcinogenic metals do not change the fidelity [4].

Carcinogenesis

DNA Reactive compounds have proved to be important in carcinogenesis. Damage to DNA can result in mutagenesis, which is involved in carcinogenesis[4]. Early experimenters found that carcinogenesis involved two distinct stages, for which the terms 'initiation' and 'promotion' were coined. Nowadays, initiation is generally equated with mutagenesis, and promoters are thought to alter the balance between growth of initiated and normal cells in favour of initiated cells, the number of which increase sufficiently to make probable a second mutagenic process that confers malignancy. Such second mutations can be induced by mutagenic carcinogens.

Few studies were done on reactions of DNA before the advent of the Watson-Crick model of DNA and its replication. Although DNA was recognized as the genetic material, its possible role as a receptor of carcinogens was confined to their binding by non-covalent van der Waals forces. Alkylating agents attack nucleophilic basic atoms, i.e , the ring-nitrogen atoms of DNA bases, thus accounting for the resultant change in the ultraviolet absorption spectrum of DNA. Using dimethyl sulfate it was found, that N7 of guanine was the most reactive atom and the more basic groups of adenine and cytosine were in fact less reactive in DNA. The methylation products of the latter basic groups were 1-methyladenine & 3-methylcytosine.[5]

Regarding the analogy between the action of Alkylating agents and of acid on DNA, it was not surprising to find that depurination of certain alkylpurines, i.e. 3- and 7-substituted deoxyribonucleotides, is much more facile at neutral pH than that of the parent purines, as found first for 7-methylguanine. This would potentiate fission of the deoxyribose-phosphate chain of the DNA macromolecule, thus accounting for the "radiomimetic" nature of methylating, and other aliphatic, alkylating agents The methylation of DNA per se was also deduced to be a potential source of cytotoxicity, since 3-methylpurines are removed from DNA by repair systems and alkylation of DNA at N3 of adenine or guanine is therefore a significant interference with the function of the DNA template

A further interesting feature of the destabilization of the imidazole ring of guanine nucleotide by alkylation at N7 is the alkali catalysed ring fission to yield a 2,3-diamino-4-oxy-5-formamidopyrimidine[5] This type of reaction has recently sprung into prominence with the findings that not only does ionizing radiation (action through OH radicals in aqueous media) attack the imidazole ring of guanine in DNA but all DNA samples contain comparatively large amounts of 8-oxypurines and the ring-opened guanine derivative. Even more notable is the finding that DNA from breast tumors contains 8-17 times the amounts in control DNA, i e., over 10^6 molecules per human diploid genome content, and the highest observed extent of chemical modification of DNA so far found[5].

Early work in which biological action was correlated with chemical damage to DNA showed clearly that cells were not inactivated reproducibly by the very low doses that induced single lethal lesions, such as cross-links in DNA. Thus, with ^{32}S-labelled mustard gas, the dose required to give one lethal hit in the genome ($6x10^6$ DNA-P) of Escherichia coli was about 72 molecules of the product of difunctional alkylation, di (guanin-7-yl) ethyl sulfide, whereas a single cross-link of this type sufficed to inactivate a double-stranded DNA phage T7, both inter- and intrastrand cross-links being lethal. This discrepancy was explained by the ability of the bacterial cell to remove the cross-links by an enzymic repair process; the mono-alkylguanine was not removed, showing it to be relatively non-lethal. A sensitive strain was unable to remove the cross-links, as shown chemcially or physiocochemically, when interestrand cross-linkage doubled the molecular weight of the alkali-denatured chromosome. During repair, DNA synthesis was temporarily halted. "Bulky" adducts, such as N2-aralkylguanine induced by 7-bromoethylbenz [a] anthracene, also proved to be effecrtive lethal lesions in T7 phage, i e. block the action of DNA polymerase[5].

The suspended lethal lesion, 3-methyladenine, and the promutagenic O^6-methylguanine were also found to be removed by repair enzymes, the lethal 3-methyladenine was removed more rapidly. It was therefore surprising that an N-glycosylase enzyme isolated from E.coli was reported to remove both types of base. It was shown subsequently that O^6-methylguanine in DNA is repaired through demethylation, with transfer of the methyl group to a cysteinyl residue of an alkyl acceptor protein, which is thereby inactivated

Whereas mouse cells, apart from liver, are not as efficient as E coli in repairing O^6-methylguanine, human cells appear to be generally proficient, although some variation was found between individuals. All mammalian cells are proficient in removal of 3-methyladenine

The "bulky" adducts and cross-links are removed by endonucleases related to those first detected by their ability to repair ultraviolet light-induced pyrimidine dimmer. The important point to emerge from these studies is that, although the cross-links are completely removed from DNA of E coli, mammalian cells effect incomplete removal and appear to survive by the ability of DNA polymerase to "by-pass" potentially lethal lesions. Although the details of the mechanisms are uncertain, one outcome is that mutations are induced in which adenine is the base preferentially inserted opposite the "non-instructional" lesion Since most "bulky" adducts are guanine derivatives, the resulting mutations are most likely, but not inevitably, GC-TA transversion. Adenine derivatives are also induced, notably by metabolized 7,12-dimethylbenz [a] anthracene, resulting in AT-TA transversions. Thus, aralkylating agents induce transversions with methylating agents, which give GC-AT transitions.

Conclusions

Two base substitutions predominate GC-At transitions and GC-TA transversions, which experimentally would reflect the action of methylating agents through O^6-methylguanine or of aralkylating agents through N2-aralkylguanines. The current consensus is that the transitions are most probably due to hydrolysis of cytosine of 5-methylcytosine in DNA. Hydrolysis of the latter to thymine would be more difficult to repair, and its predominance is supported by the observations that the majority of transitions occur at CpdG "hotspots". Deficiency in repair would be expected to enhance initiation of tumours, and that was the case for patients with the rare inherited disease xeroderma pigmentosium [(4)].

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WATER BORNE DISEASES

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ABSTRACT Poor quality drinking water is the major factor in spreading of bacterial, viral and parasitic diseases amongst human beings and other domestic as well as wild animals

Introduction

Water is a basic, indeed an absolute requirement for the survival of human race, potable and safe drinking water being essential for the health and well being of the community

Over 70 percent of body mass in an average normal human adult consists of water This means 50 liters of water in a 70 Kg man Without adequate amount of water in the internal body environment, vital metabolic functions will be seriously jeopardized in the human organism

Unfortunately clean water for human consumption is fast becoming a costly and difficult-to-obtain commodity available only to the lucky few, particularly in the third world countries where a major section of the population in the rural as well as urban communities is without clean drinking water

Water supplies, even in reasonably good set-ups are frequently subject to contamination by biological and to a lesser extent by chemical impurities which are responsible for a variety of illnesses in man. The causal agents of these illnesses commonly transmitted through drinking water include pathogenic organisms like bacteria, viruses, protozoa and parasitic worms on the one hand and some poisonous chemical substances on the other

Table 1 lists major diseases which are transmitted through the use of water with particular reference to their prevalence in our country.

Table 1. *Diseases due to Microbial Contamination*

Bacterial	Viral	Parasitic
Salmonellosis Shigellosis Cholera	Hepatitis A Hepatitis E	Amoebiasis Giardiasis Helminthiasis Round worm Pin worm Guinae worm Amoebic meningoencephalitis

Lead poisoning (Plumbism) is the one of the most important and the best known water borne diseases caused by a chemical poison followed by fluorosis, dental caries and others.

A brief account of microbiological and epidemiological aspects of some of these diseases is given in the following paragraphs

Salmonellosis

A broad term which is applied to a disease complex caused by infection with any of the more than 2200 serotypes of Salmonellae, which are gram negative motile rods inhabiting human and animal intestine Clinically and microbiologically, salmonella infection falls into two major patterns (Keusch 1991).

1 Typhoidal · Typhoid or Enteric Fever
2 Non-typhoidal Entero-colitis

Each of these clinical entities is associated with specific salmonella serotypes and in both, the organisms are transmitted by ingestion of contaminated food and water

Typhoid (Enteric Fever)

An acute febrile illness caused by S. typhi or S paratyphi-A & B and characterized by the invasion of blood stream by salmonellae. Large outbreaks of typhoid are usually water borne while small out breaks and sporadic cases are usually food borne. Incubation period varies from 10-14 days Man is the only reservoir and source of infection, as no animal is known to suffer from typhoid fever Majority of cases can be traced to a human carrier. A patient or a carrier excretes viable salmonellae in stool which contaminate food and water, when taken by another individual, infection is promptly transmitted. On reaching the intestine, organisms invade the mononuclear phagocytes in the gut wall through which they are carried to the blood stream via the lymphatics causing a sustained bacteraemia and septicaemia resulting in persistent fever

Clinically, typhoid is characterized by a slow, step-ladder type of rise in temperature over a period of 7-10 days. If untreated the fever lasts for 4-8 weeks and may lead to haemorrhage and perforation of the gut wall Specific treatment promptly cuts short the course of the disease and prevents complications. If untreated, typhoid mortality may be as high as 10-15%. Specific Therapy reduces the mortality to less than 1% Typhoid is one of the two treatable causes of fever commonly seen in our country, the other one being malaria.

A proportion of cases of typhoid may become carriers Temporary carriers (about 10%) excrete salmonellae in their faeces for upto one year, 2-5% may become long term/permanent carriers, excreting the organisms intermittently or continuously over prolonged periods.

Prevention & Control

Clean and potable drinking water is the mainstay of prevention and control of typhoid Carriers should never be allowed to work as food handlers

Enterocolitis

Enterocolitis, commonly termed as gastroentritis, is by far the commonest manifestation of salmonella infection and is caused by serotypes other than S typhi and paratyphi, S typhimurium being the commonest and the best known The illness has an incubation period of 4- 48 hours and is characterized by diarrhea, vomiting, colic and fever In the vast majority of cases, it is a self-limiting condition with complete recovery in 3-5 days As a rule, salmonellae remain confined to the intestinal tract Unlike typhoid, these, serotypes also infect animals and poultry which are frequently the source of human infection.

Shigellosis

Shigellosis or bacillary dysentery is one of the commonest causes of bloody diarrhea in this country and is caused by any of the four species of Shigella, which are gram negative non-motile rods and which, like typhoid salmonellae, are exclusively human pathogens, and the infection remains confined to GIT Highly communicable from person to person with a low infective dose (1000 organisms only), shigella dysentery has an incubation period of 1-2 days After ingestion of contaminated water or food there is sudden onset of diarrhea with mucous and blood, fever and abdominal colic 50% of the patients recover spontaneously in 2-5 days.

Shigellae are excreted in the faeces for 2-3 weeks. Chronic carriers are rare and the mortality is less than 1%

Cholera

Predominantly as Asian disease with pandemic spread, cholera is characterized by explosive onset of profuse watery diarrhea with rice water stools and vomiting leading to rapid dehydration and circulatory collapse If untreated, death occurs within a few hours in more than 50% cases.

Vibrio cholera or comma bacillus, the etiological agent of cholera, is a highly motile gram negative curved rod which infects the human intestine and produces a powerful cholera toxin. This toxin causes massive hyper-secretion of water and electrolytes resulting in profuse watery diarrhea with fluid loss of upto 30 liters per 24 hours

Epidemiology

Source is almost always faecal contamination of water from an infected person, vibrios survive in water for upto three weeks Since gastric acidity is lethal to the vibrios, a high infective dose (upto 10) is required and only 1- 5% of those exposed become ill However, if gastric acidity is buffered by a heavy meal, a lesser infective dose will initiate illness In between outbreaks and sporadic cases, Vibrio cholerae is maintained by continuous transmission through subclinical infections

Management & Prevention

With modern approaches to management, no patient of cholera should die if dehydration therapy is started in time along with appropriate antibiotics. Vibrio cholerae remains fully susceptible to doxycycline and nalidixic acid Sanitary measures especially careful attention to water supply will effectively control the spread of cholera in the community

Water Borne Viral Hepatitis

Among the several different forms of viral hepatitis known so far (named alphabetically from A to G), only the causative agents of Hepatitis A and E are transmitted through the faecal-oral route. Whereas drinking water is the major vehicle of infection in Hepatitis E, water bone injection of Hepatitis A is not uncommon

Hepatitis A and E are the commonest causes of jaundice in this country Hepatitis A, both overt and subclinical, is extremely common, by the age of 15, 95% of the population becomes immune. Both the viruses are excreted in stools of infected individuals and both produce essentially a benign and self-limiting infection with no chronic sequelae However there are also significant differences between the two as given in Table 2

Table 2 *Important Indices of Hepatitus A & Hepatitis E*

Indices	Hepatitus A	Hepatitus E
Incubation Period	15-45 days (Ave 23 days)	3-9 weeks (Ave 6 weeks)
Age incidence	Max upto 15 yrs	Max 15-45 years
Out breaks	Moderate, person to person spread	Large epidemics usually water-borne
Mortality	< 0 1 %	Upto 3%, 20-40% in pregnancy
Immunity	Life long	Undetermined
Household contacts	Attack rate 10 - 20%	< 3 %

There was a large out break of water-borne Hepatitis E in two sectors of Islamabad in 1993-94 which affected 3700 inhabitants (almost 10% of the population) in these sectors (Dil 1994) Serological and EM confirmation was made in selected cases.

Parasitic Infections

Some of the common parasitic infections in which contaminated drinking water plays a major role in transmission, include Amoebiasis (amoebic dysentery), Giardiasis and the common round worm infestation (Ascariasis)

Amoebiasis

Primarily an intestinal infection by a Protozoan, Entamoeba histolytica, it can manifest itself as Amoebic Dysentery (Intestinal Amoebiasis) or as Amoebic Hepatitis and liver abscess (Extra-intestinal Amoebiasis).

Asymptomatic carriers usually pass several million amoebic cysts daily in their stool which are transmitted through contaminated water or food among the general population

According to conservative WHO estimates, 10% population of the world at large and 50% in the developing countries suffers from amoebiasis which directly results in 40 million disabling infections and about 45000 deaths annually mostly in the third world countries

Giardiasis

Giardia lamblia, a common intestinal protozoan, is probably the single most frequent cause of water-borne out breaks of diarrhea especially in young children More than 20% population of the developing world is infected, with faecally contaminated water containing cysts being the major source of infection

Ascariasis

Ascaris lumbricoides is the largest round worm which afflicts man and which has a world wide distribution Prevalence may be as much as 50% in some communities and most susceptible section of the population appear to be children of pre-school and early school age.

Each female round worm produces upto 200,000 eggs per day which are passed in stool When the larvae have developed in these eggs in 10-50 days, they are highly infective when ingested in water or green vegetables. Drinking boiled water, hand washing and avoiding raw vegetables or washing them before eating will effectively break the chain of transmission.

Lead Poisoning - Plumbism

Lead is the commonest poisonous metal which may gain entry into water supplies Major source is the exhaust fumes from automobiles followed by lead pipes used in the past for water distribution and leaded paints.

Exhaust fumes from leaded petrol are slowly deposited on the soil and on the surface of large bodies of water (lakes and dams) from where the metal gradually finds its way into drinking water. Ingested lead is absorbed through GIT and produces a cumulative effect over prolonged periods resulting in typical features of Plmbism like wrist drop and a characteristic blue line at the junction of gums and teeth

In a recent study (Hafeez & Malik, 1996), 90% of pre-school children aged between 1 and 5 were found to have blood levels above the acceptable limit of 10 $\mu g/dl^{-1}$ Besides drinking water, pica was found to be a common source of increased lead levels in these children

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DRINKING WATER QUALITY GUIDELINE VALUES CHEMICAL AND PHYSICAL ASPECTS

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ABSTRACT: The assessment of toxicity of drinking-water contaminants can be made reliably through quality guideline values based on drinking-water consumption as a function of body weight, ingestion and indirect exposure, health risk evaluation and tolerable daily intake limits Using existing international methodology, procedure is defined for obtaining guideline values, for inorganic, organic, pesticide and disinfectant contaminants in drinking-water Tabulated data on these contaminants are made available for dissemination to environmental researchers engaged in water quality assessment or regulation

Introduction

Water is a vital natural resource It covers about 80% of earth's surface and plays a key role in sustaining life on this planet. About 2 5 % of the total 1,360 million km^3 water on earth is fresh, most of it locked up in deep aquifers or frozen in ice caps and only 33,400m^3 of water is available for drinking, agricultural, domestic and industrial purposes. In the past years growth of population and rapid industrialization not only raised the demand for more water but have played an instrumental role in deteriorating the quality of aquifers. This has resulted in a rise of water borne diseases . Over 70 % of the world's population depends on water from uncertain sources which may be contaminated with industrial as well as domestic wastes It is estimated that, due to the anticipated doubling of the world population as well as further industrialization and growth in the size and density of our urban centers, the amount of fresh water available per person will decline by 24 % in the year 2000[1]

The unique solvent properties of water not only provide a base for different biological and phsico-chemical processes but also make it susceptible to contaminants arising from various anthropogenic and natural activities, consequently, pollutants from industrial processes, municipal waste and agricultural run-off enter the aquatic system directly or through different pathways, they change the physico-chemical and biological properties of water and render it unfit for human consumption The water pollutants can be organic including oxygen demanding wastes like domestic and animal sewage, biodegradable organic compounds, wastes from food processing plants, meat-packing plants, slaughter-houses, paper and pulp mills, tanneries etc., disease-causing agents including pathogenic microorganisms (like viruses and bacteria responsible for dangerous water-borne diseases like cholera, typhoid, dysentery, polio and hepatitis), synthetic organic compounds like pesticides, detergents, food additives, pharmaceuticals, insecticides, paints, synthetic fibers, elastomers, solvents, plasticizers, plastic and oil or inorganic comprising of metals or metal compounds, trace elements, mineral acids, inorganic salts, cyanides, sulphates, nitrates polyphosphate and organometallic compounds

Industrial wastes are the main culprit for water pollution in areas close to Industrial zones The waste water generated by industries like textile, pharmaceutical, tanneries, plastic and rubber, metal and electroplating, glass and ceramics, chemical, soaps, detergents, paints, pesticides, food processing and steel mills contain large amounts of organic pollutants, heavy metals, suspended and dissolved solids. Manufacturing industries also generate a variety of solid or semi-solid waste having toxic organic and inorganic constituents Leaching of hazardous materials from solid waste (garbage, rubbish, pathological and agricultural waste) dumps also pose threat to the nearby water bodies. In urban areas the seepage of sewerage into the drinking-water distribution systems is also of utmost concern

The problem of water pollution due to discharges of domestic and industrial wastes into aquatic systems has already become a serious problem in Pakistan[2-4]. Nearly 90% of Pakistan's population is exposed to unsafe drinking water According to an early estimate consumption of sewage contaminated water would account for 30 % of all reported diseases and 40 % of all deaths in Pakistan[5] In 1980 the WHO recorded 3150 cases of waterborne diseases per million population[6], another report showed that in 1981 there were at least 50,000 cases of typhoid and paratyphoid fevers alone in Pakistan[7], according to another estimate the annual number of cases of waterborne infections in Pakistan may be close to 3 million[8] The groundwaters are also under pollution stress, especially near industrial areas[9].

Improper waste disposal practices resulting in the death of humans through contamination of water systems has raised worldwide concern. In order to ward off the human health against the ill effects of contaminated waters, there is a dire need for establishing quality guideline value for the physical, microbiological and chemical safety of drinking water. The present attempt reflects this aspect.

Necessary Background Information

Following information is critical for monitoring and impact assessment studies on water quality. Only brief outline in each case is provided.

Sources of Daily Intake

Inhalation, direct ingestion, dermal contact during bathing and showering

Risk Assessment

Studies on human population, toxicity studies on lab animals, studies on dose - response relationship, expert judgment

Background data for Developing guidelines

Published reports from open literature, government reports; unpublished proprietary data, existing international information, previous risk assessment studies (Government & NGOs), World authority data such as programme on chemical safety IPCS (International Health criteria), EHC (Environmental Health criteria), IARC (International Agency for Research on Cancer), and FAQ/WHO expert committees, etc.

Water Consumption and Body Weight Criterion

Water consumption data are limited, Consumption of water varies with climate, physical activity and culture, and temperature,

For potentially hazardous chemicals, a daily per capita consumption of 2L by a person weighing 60 kg is assumed,

For high intakes (e g for infants and children) higher exposure is expected,

Irreversible effects (social, public health) are more drastic in young age,

Guidelines for 10kg child (1L/day) or 5kg infant (consuming 0 75 L/day) are different

The Tolerable Daily Intake (TDI)

This is defined as NOAEL and LOAEL given as under alongwith a few other definitions

- NOAEL highest concentration of a substance that causes no detectable adverse health effect,
- LOAEL: Lowest observed concentration of a substance at which there is a detectable adverse health effect, and
- UF uncertainty factor, for interspecies variation, usually 1-10

$$\Delta TDI = \frac{NOAEL\ (or\ LOAEL)}{UF}$$

Here, ΔTDI = f (amount of substance mg kg-1, µg kg-1 of body weight that can be ingested daily over a lifetime without appreciable health risk).

From ΔTDI, we obtain GV (guideline value)

$$GV = \frac{TDI \times W \times P}{C}$$

Where

W = 60kg body weight for adult, 10 kg for children, 5kg for infants, P =fraction of TDI allocated to drinking water and C = daily consumption of drinking-water (2L for adults, 1L for children, 0 75L for infants)

In view of all this, Joint FAO / WHO Expert Committee on Food Additives (JECFA) and Joint FAO/WHO Meeting on Pesticide Residues (JMPR) have developed acceptable density intake ADIs for water Data relevant to water quality criteria are now summarized in Tables-1 to 8

Table 1 *Chemicals not of health significance at concentrations normally found in drinking water*

Chemical	Remarks
asbestos silver tin	It is unnecessary to recommend a health based guideline value for these compounds because they are not hazardous to human health at concentrations normally found in drinking water

Table 2: *Various paramerters and constituents responsible for water pollution*

Physical parameters Inorganic constituents	Colour, Hardness, pH, Taste & odour, TDS, Turbidity Al, NH_3, Sb, As, Asbestos, Ba, Be, B, Cd, Cl_2, Cr, Cu, CN^-, F^-, H_2S, Fe, Pb, Mn, Hg, Mo, Ni, NO_3^-, NO_2^-, DO, Se, Ag, Na, SO_4^{2-}, Sn, U, Zn
Organic Constituents (consequence of disinfection)	Carbon tetrachloride, dichloromethane, dichloroethane, trichloroethane, vinyl chloride, dichloroethane, tri & tetrachloroethene, benzene, toluene, xylene, styrene,polynuclear aromatic hydrocarbons, chlorobenzenes, pthalates, amides, etc
Pesticides & herbicides (agricultural run-off)	numerous (as many as 30)
Disinfectants	Chloramines chlorine, Chlorates, Iodine, Bromates, Chlorophenols, formaldehydes, trihalomethanes, Chloro acetone, halogenated acetonitriles
Radiological contaminants	(Various)

Table 3 *Bacteriological quality of drinking water*

Organisms	Guideline value
All water intended for drinking E coli or thermotolerant coliform bacteria	Must not be detected in 100 ml sample
Treated water entering the distribution system E coli or thermotolerant coliform bacteria Total coliform bacteria	Must not be detected in 100 ml sample Must not be detected in 100 ml sample
Treated water in the distribution system E coli or thermotolerant coliform bacteria Total coliform bacteria	Must not be detected in 100 ml sample Must not be detected in 100 ml sample In the case of large supplies, where sufficient samples are examined, must not be present in 95 % of samples taken throughout any 12-month period

Table 4: *Chemicals of health significance in drinking water*

A Inorganic constituents

	Guideline value (mg/L)
antimony	0 005 (P)
arsenic	0 01 (P)
barium	0 7
beryllium	NAD
boron	0 3
cadmium	0 003
chromium	0 05 (P)
copper	2 (P)
cyanide	0 07
fluoride	1 5
Lead	0 01
Manganese	0 5 (P)
Mercury (total)	0 001
molybdenum	0 07
nickel	0 02
nitrate(as NO_3^-)	50
nitrite (as NO_2^-)	3 (P)
selenium	0 01
uranium	NAD

B: Organic Constituents

Organic compound	Guideline value (µg/L)
a. Chlorinated alkanes	
Carbon tetrachloride	2
Dichloromethane	20
1,1-dichloroethane	NAD
1,2-dichloroethane	30
1,1,1-trichloroethane	2000 (P)
b. Chlorinated ethenes	
Vinyl chloride	5
1,1-dichloroethene	30
1,2-dichloroethene	50
trichloroethene	70 (P)
tetrachloroethene	40
c. Aromatic hydrocarbons	
benzene	10
toluene	700
xylenes	500
ethylbenzene	300
styrene	20
benzo[a]pyrene	0 7
d. Chlorinated benzenes	
monochlorobenzene	300
1,2-dichlorobenzene	1000
1,3-dichlorobenzene	NAD
1,4-dichlorobenzene	300
trichlorobenzene (total)	20
e. Miscellaneous organics	
Di(2-ethylhexyl)adipate	80
Di(2-ethylhexyl)- phthalate	8
Acrylamide	0 5
Epichlorohydrin	0 4 (P)
Hexachlorobutadiene	0 6
Edetic acid (EDTA)	200 (P)
Nitrilotriacetic acid	200
Dialkyltins	NAD
Tributytin oxide	2

C: Pesticides

Pesticide	Guideline value (µg/litre)
alachlor	20
aldicarb	10
aldrin/dieldrin	0 03
atrazine	2
bentazone	30
carbofuran	5
chlordane	0 2
chlorotoluron	30
DDT	2
1,2-dibromo-3-chloropropane	1
2,4-D	30
1,2-dichloro- propane	20 (P)
1,3-dichloro- propane	NAD
1,3-dichloro- propene ethylene dibromide	20
heptachlor and heptachlor epoxide	0 03
Hexachloro-benzene	1
Isoproturon	9
Lindane	2
MCPA	2
methoxychlor	20
metolachlor	10
molinate	6
pendimethalin	20
pentachlorophenol	9 (P)
permethrin	20
propanil	20
pyridate	100
simazine	2
trifluralin	20
chlorophenoxy herbicides other than 2,4-D and MCPA	
2,4-DB	90
dichloroprop	100
fenoprop	9
MCPB	NAD
mecoprop	10
2,4,5-T	9

D. Disinfectants and disinfectant by-products

Disinfectants	Guideline value (mg/L)
monochloramine	3
di- and trichloramine	5
chlorine dioxide	not established
iodine	NAD
bromate	25 (P)
chlorate	NAD
chlorite	200 (P)
chlorophenols	
2-chlorophenol	NAD
2,4-dichlorophenol	NAD
2,4,6-trichlorophenol	200
formaldehyde	900
MX	NAD
trihalomethanes	
bromoform	100
dibromochloro-methane	100
bromodichloro-metane	60
chloroform	200
chlorinated acetic acids	
monochloro-acetic acid	NAD
dichloroacetic acid	50 (P)
trichloroacetic acid	100 (P)
chloral hydrate	
(trichloroacet-aldehyde)	10 (P)
chloroacetone	NAD
halogenated acetonitriles	
dichloroaceto-nitrile	90 (P)
dibromoaceto-nitrile	100 (P)
bromochloro-acetonitrile	NAD
trichloroaceto-nitrile	1 (P)
cyanogen chloride (as CN)	70
chloropicrin	NAD

(P) Provisional guideline value

NAD No adequate data to permit recommendation of a health-based guideline value

Table 5. *Maximum allowable concentration of various toxic elements and bacteriological quality of drinking water*

Lead (as Pb)	0 1 mg/l
Selenium (as Se)	0 05 mg/l
Arsenic (as As)	0 2 mg/l
Chromium (as Cr Hexaalent)	0 05 mg/l
Cyanide (as CN)	0 01 mg/l
Fluorides	1 0-1 5 mg(max) 0 5 mg/l (minimum must)
Nitrates	50-100 mg/l
Bacteriological Quality	a) Untreated water MPN* = 10 -20 b) Treated water MPN = < 1

* MPN Most probable No , index of coliform micro-organism contamination

Table 6: *Radioactive constituents of drinking-water*

	Screening value (Bq/litre)
gross alpha activity	0 1
gross beta activity	1

Table 7: *Substances and parameters in drinking-water that may give rise to complaints from consumers*

Parameter	Levels likely to give rise to consumer complaints	Reasons for consumer complaints
	a. Physical parameters	
Colour	15 TCU	appearance
taste and odour	-	should be acceptable
Temperature	-	should be acceptable
Turbidity	5 NTU	apperance, for effective terminal disinfection, median turbidity ≤1NTU, single sample ≤5NTU
	b Inorganic constituents	
Aluminium	0 2 mg/L	depositions, discoloration
Ammonia	1 5 mg/L	odour and taste
chloride	250 mg/L	taste, corrosion
copper	1 mg/L	staining of laundry and sanitary ware (health-based provisional guideline value 2 mg/L)
hardness	-	high hardness scale deposition, scum formation low hardness. possible corrosion
hydrogen sulfide	0 05 mg/L	odour and taste
iron	0 3 mg/L	staining of laundry and sanitary ware
manganese	0 1 mg/L	staining of laundry and sanitary ware (health-based provisional guideline value 0 5 mg/L)
dissolved oxygen	-	indirect effects
pH	-	low pH corrosion
sodium	200 mg/L	taste
sulfate	250 mg/L	taste, corrosion
total dissolved solids	1000 mg/L	taste
zinc	3 mg/L	appearance, taste
	c Organic constituents	
toluene	24-170 µg/L	odour, taste (health-based guideline value 700 µg/L)
xylene	20-1800 µg/L	odour, taste (health-based guideline value 500 µg/L)
ethylbenzene	2-200 µg/L	odour, taste (health-based guideline value 300 µg/L)
styrene	4-2600 µg/L	odour, taste (health-based guideline value 20 µg/L)
monochloro-benzene	10-120 µg/L	odour, taste (health-based guideline value 300 µg/L)
1,2-dichloro-benzene	1-10 µg/L	odour, taste (health-based guideline value 1000 µg/L)
1,4-dichloro-benzene	0 3-30 µg/L	odour, taste (health-based guideline value 300 µg/L)
trichlorobenzene (total)	5-50 µg/L	odour, taste (health-based guideline value 20 µg/L)
synthetic detergents	-	foaming, taste, odour
Disinfectants and disinfectant by-products		
chlorine	600-1000 µg/L	taste and odour (health-based guideline value 5 mg/L)
chlorophenols		
2-chlorophenol	0 1-10 µg/L	taste, odour
2,4-dichlorophenol	0 3-40 µg/L	taste, odour
2,4,6-trichloro-phenol	2-300 µg/L	taste, odour (health-based guideline value 200 µg/L)

TCU true colour unit
NTU nephelometric turbidity unit

Table 8: *Drinking water specifications*[10]

Parameter	Permissible levels	Excessive levels
Total solids	500 mg/l	1500 mg/l
Colour	5 units	50 units
Turbidity	5 units	25 units
Taste	Unobjectionable	------
Odour	Unobjectionable	------
Iron (Fe)	0 3 mg/l	1 0 mg/l
Manganese (Mn)	0 1 mg/l	0 5 mg/l
Copper (Cu)	1 0 mg/l	1 5 mg/l
Zinc (Zn)	5 0 mg/l	15 mg/l
Calcium (Ca)	75 mg/l	200 mg/l
Magnesium (Mg)	50 mg/l	150 mg/l
Sulphate (SO_4^{2-})	200 mg/l	400 mg/l
Chloride (Cl)	200 mg/l	600 mg/l
pH range	7 0 - 8 5	Not less than 6 5 or greater than 9 2
Magnesium + sodium sulphate	500 mg/l	1000 mg/l
Phenolic substances (as phenol)	0 001 mg/l	0 002 mg/l

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MEMBRANES AND OTHER PROCESSES TO IMPROVE THE QUALITY OF DRINKING WATER

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ABSTRACT Recent developments in economical and industrial fields, coupled with population enhanced load has resulted into further demands for the potable and drinking water supplies In the urban and rural areas of Pakistan the quality of drinking water has been a point of discussion and attention since long Contributions of the toxic metal ions and bacteria normally challenge the health of the people Recently available technology in the membrane field has provided reverse osmosis and electrodialysis processes for water demineralization and removal of the undesired components from water for public consumption In fact reverse osmosis has gained lead over electrodialysis being a simple, type of filtration process, working under mechanical pressure and also having applicability to sea water desalination The role of this and the other processes to remove the cations, anions and bacteria has been discussed The benefits of the reverse osmosis and other filtration processes have been described for general awareness The use of ultraviolet light rays as a water disinfectant has also been discussed

Introduction

The health of the people is of prime importance. The drinking water supplies in Pakistan have been some times deteriorated to harm the health of the users. Therefore water quality is to be ensured. Quality of water is challenged by (i) suspended materials (ii) dissolved materials, which are both organic as well as inorganic in nature and (iii) bacteria, viruses, protozoa To get rid of these three types of species, spoiling water quality, there are different water purification methods[1-2] These are classical as well as modern techniques. The modern techniques are based on membranes and other chemical and physical processes The use of the given processes depends upon the type of impurities present. In this article the role of some of these processes to purify water has been described. This article will be limited to some of the toxic metal ions with a brief reference to the bacteria and viruses present in water and how to get rid of these It can be noticed that in Pakistan 5.75 million hectares of land has underground water with less than 1000PPM concentration and 1.84 million hectares with concentration range of 1000-3000PPM and 4.29 million hectares with concentration > 3000 PPM[3,8]. As such 52% of C.C.A. has under ground saline water, which stresses the need for the desalting techniques to be applied to use the full potential of water for drinking as well as agriculture purpose.

Limiting Values of Dissolved Ions

The limiting amounts of various ions, which affect the quality of water are given in Table 1[4]. It may be noted that though the limiting values for different ions in different countries are not the same but should not exceed certain maximum levels e.g. the toxic elements like, As, Ba, Cd, Cr, Fe, Mn, etc should not be allowed to be present above a given concentration level, as shown in Table-1.

Different Water Treatment Processes

There are different treatment techniques to remove or reduce the level of dissolved metal ions and bacteria from water, these are:

(i) precipitation;
(ii) flocculation Sedimentation;
(iii) filtration;
(iv) desalting by membrane process and distillation; and
(v) disinfection using U.V. radiation

The use of these systems to remove various impurities is provided below:

Table 1: *Limiting Values for Trace Metals and other Ions in Drinking Water (Mg/M^3)[4]*

	WHO	E.C	Switzerland	France	U.S.A.	Germany
Aluminium (Al)	-	50	500	-	-	200
Arsenic (As)	50	50	-	50	50	40
Barium (Ba)	-	100	-	-	1000	-
Lead (Pb)	100	50	50	50	50	40
Cadmium (Cd)	10	5	10	5	10	6
Chromium (Cr)	-	50	20	50	50	50
Iron (Fe)	100/1000*	300	100	100	50-300	200
Fluorine (F)	600/1700*	700-1500	1500	1500	1400-2400	1500
Copper (Cu)	50/1500*	50	1500	50	200-1000	-
Manganese(Mn)	50/500*	50	50	50	10-50	100
Nitrate (NO_3^-)	45	50	40	50/100	45	50-90
Mercury (Hg)	1	1	3	1	2	4
Selenium (Se)	10	10	-	10	10	8
Silver (Ag)	-	10	200	-	50	100
Zinc (Zn)	5000/15000*	100/2000	1500	-	5000	100/2000

*Highest required value/Maximum permissible value.

Precipitation Flocculation and Filtration to Remove Toxic Metal Ions

Removal of Fe and Mn

Precipitation is an old method Removal of Fe and Mn by this process is discussed here. In well water Fe and Mn occurs as Fe^{++} & Mn^{++} and are to be removed for technical and hygienic reasons. These ions are oxidised by ozone, $KMnO_4$ or oxygen to Fe(III) and Mn(IV) , which precipitate and are removed after filtration Conversion of Fe(II) to Fe(III) is fast and that of Mn(II) to Mn(IV) is slow but $Mn(OH)_4$ works as a catalyst to enhance the reaction[4] Oxidation is normally done by saturation of water with atmospheric oxygen

Removal of other Elements

Among the condition of the removal of the toxic elements, like As, Ba, Cd, Cr (III & IV), Pb, Hg, Se, Ni, Cu and Zn, the parameters like pH of the feed water, valencey of metallic ions, amount of flocculate and the type of flocculant added, the initial concentration of the ions present, and the turbidity are to be determined and the feed conditions are to be fixed. The metallic ions concentration limits are shown in Table-2.

Table 2: *Limits of Metallic Ions Concentration in Water*[6]

	Min.	g/m^3	Max.
As (V)	0.10	---------	0 40
Ba	1 00	---------	8 00
Cd	0.10	---------	0 40
Cr (III)	0.10	---------	0 40
Cr (VI)	0.05	---------	0.20
Hg	0.01	---------	0 05
Se (IV)	0.01	---------	0 04
Ni, Cu, Zn	1.00	---------	4 08

These elements behave differently and their removal depends on pH. using a pH of 6.5-7, and a flocculant admixture of $5g/m^3$ Fe(III), As(IV), Cr(III), Pb(II) is removed after precipitation up to > 90% or more under these conditions, Ba and Cr(VI) are precipitated and removed to only a very small extent.

If we use a pH of 7.5 - 8, with all other conditions keeping the same, Ag, Cd and Hg are better precipitated Se(VI) precipitates poorly. Cr(VI) can be removed after reducing it with Fe^{+2} and precipitating at pH 8-8 5. Upto 95% of Cr(VI) can be removed in this way.

At pH 10 - 10.5, by means of decarbonization, flocculation, and scdementation by an admixture of $5g/m^3$ of Fe(III), good separation of a number of metal ions along with Ba is possible but Cr(VI) and Se(IV) are not removed[6]

These are just a few examples to indicate that while treating the water a very careful consideration is to be given to the parameters described above, to get a good quality supply of water

Activated Alumina and Carbon Filters

(i) Alumina

Alumina is a porous form of Al_2O_3 with 150-400m^2 specific area per gm of Al_2O_3 and density app 3.3g/cm^3, used for the removal of As, Se and fluoride ions. It may be in different grain sizes. For usually present Fe, Se and As concentration levels, at a pH of 5-5 5, alumina column can treat about 1000 time volume of water compared to its own volume, before regeneration with 0.5-1% NaOH The specific loadability is 50-70mg/dm^3, for Se and 10-15mg/dm^3 for As(IV) and needs more conc of NaOH to regenerate the column. The system involves prior flocculation, sedimentation, settling, sand filtration and then adsorption by alumina.

Activated carbon filters remove both organic as well as inorganic Hg A contact time of 6-12 minutes removes upto 200mg/dm^3 of Hg organometallic compounds of Hg.

(ii) Activated Carbon

Absorbs low mol.wt. organics, chlorine, odour producing nutrients from water, works well on 60-300 mol wt. materials. Does not remove salts but absorbs some metal ions. If not replaced after given intervals of time, produce large colonies of bacteria and large amounts of pyrogenic materials.

Membrane Processes

There are a number of water treatment systems based on membranes. These are based on filtration or appear to be based on simple principle of filtration. These are briefly described below.

There are different engineering configurations[1] of these processes modules e.g. spiral wound, hollow fibre or tubular modules, which are not described here in detail for the sake of brevity.

(i) Microfiltration

Removes from 100μm to 0.10μm size species from water e.g. pollen (100μm), starch (10μm), blood cells (1μm), bacteria (1μm to 0.1μm)

(ii) Ultrafiltration

Removes species from 0.01μm to 0.001μm size e.g. DNA, viruses (0.01μm), albumin (0 01μm), glucose (0.001μm).

(iii) Reverse Osmosis (R.O) or Hyperfiltration

Removes all the above sized species along with dissolved solutes e.g. NaCl, Kcl. These all use membranes, which reject given species under different levels of mechanically applied pressures, by pumping. The membrane life is 1-3 years. Removes all organics of mol.wt $\geq$ 200. Removes > 95% salts from brackish water. Two stages remove 99.9% salts. All bacteria, viruses and pyrogens are removed Membranes are affected by the pH and chemical conditions It has been applied to both sea and brackish waters. It is cheaper, less capital intensive, simple and easily applicable to home water purification Systems which use low pressures can be produced. For that purpose membranes, which have large fluxes, are to be used; which can be produced and applied in Pakistan It is now industrially preferred process to distillation in all respects. Consumes less energy. The users and suppliers need to be educated for the type of membranes and R.O systems to suit their requirements.

(iv) Electrodialysis

This process is based on cation (CEM) and anion (AEM) exchange membranes, which are arranged in the form of a number of membrane pairs. Water is run between CEM and AEM, under the applied current and voltage. The ions are pulled out of the flowing liquid through the membrane, thereby reducing the concentration from there (called diluate stream) and concentrating the other stream known as (concentrate stream)

At a time hundreds of membrane pairs are fixed So the energy consumed is economised This process is applicable to water upto 3000ppm concentration and normally used to reduce the concentration upto 500-800ppm After that the resistance of the system increases to enhance the overall energy required. This system works at a pumping pressure of nearly 60 psi

(v) Distillation and Non-membrane Processes

It is the change of the phase process and has been used extensively in the past In the present form, it exists as multistage flash distillation (Fig 3) and multi-effect boiling, recovering heat from the vapours, transferring to the incoming cold feed streams to increase the overall efficiency of the plant to distill water As such there are plants, which can convert 12-16 k gms of water per Kg of steam. All the inorganic impurities, including toxic metals ions can be removed to recover pure water, which normally evaporate at temperature higher than that of water. Hence for producing drinking water quality, the distillate is mixed with higher salinity water This consumes more energy, when used for desalination of water. Many million gallons per day capacity plants are working in different parts of the world, including Middle East, Russia and Japan. It involves higher capital as well as running costs to get distilled water The triple distilled waters are used to get rid of pyrogens to be used in dialysis of blood.

Vapour compression based distillation systems are there as well. This is not competitive with membrane processes. Freezing is another phase change process, which is based on the principle of freezing the saline water, when the crystals formed are free of salts and after washing and melting provide pure water The latent heat of water freezing, being less than that of the latent heat of water vaporisation seems to have involved less energy, but this process efficiency is outset due to the difficulty in pumping or transporting solid water crystals.

(vi) Ion-exchange Process

Ion exchange resins are used for deionisation The anion exchange resins (AER) can remove anions and cations exchange resins (CER), the cations. CER are regenerated to (H^+) and AER to (^-OH) forms As such Ca^{++}, Mg^{++}, Na^+ and K^+ get exchanged with H^+ and Cl^-, SO_4^{-2}, F^-, NO_3^-, with ^-OH The purified water as such will have H^+ and ^-OH which combine to form H_2O. But the level of H^+ and ^-OH present in purified water may be in different amounts The ions are absorbed in the following order first

Cations: $Ca^{+2} > Mg^{+2} > K^+ > Na^+ > H^+$

Anions: $NO_3^- > SO_4^{-2} > NO_2 > Cl^- > HCO_3^- > {}^-OH = F^-$

This is why to remove Ca^{+2} and Mg^{+2} from water the resins are regenerated by Na^+ or H^+

Deionisers do not remove organics, virus or bacteria, but rather some times give way to bacterial colonies if not replaced for a longer periods. Normally used for removing Ca^{++} and Mg^{++} ions from feed supplies, if present above a given level

U.V. Disinfection

The U V. radiations are produced by passing current through low pressure Hg vapours contained in an evacuated tube The U.V range for killing microbes is 200-300nm. The radiations kill viruses, algae, bacteria, protozoa and fungi. 254nm wave length radiations are close to the most effective killing wavelength of 260nm being maximumly adsorbed E-coli require $7x10^3$ microwatt/s cm^2 and protozoa 10 $5x10^4$ mw/sec cm^2. U.V energy dose = Intensity x contact time in seconds U V.transmission at >75% is required at 254nm wavelength radiation So water to be treated should be free of suspended constituents

Humic acid, tannins and Fe are found in water and absorb U V radiation to reduce its disinfecting action Ca and Mg ions if precipitated may also reduce effectiveness of this process. So precipitate and filter the suspended precipitates from water before applying U V. radiation

The U V tube is recommended to be sleeved, other wise its relative efficiency will decrease with temperature 5-1000 gallon per minute purifier are available. The system life claimed is 6000 to 12000 hrs. Required dose for disinfectrion is 38000 mw/s cm^2 for contaminated waters and 1600 mw/s cm^2 for normally supplied water[7] As different doses are to be given to kill different type of harmful bacteria, so the product samples are needed to the tested to fix the U V.dose and ensure quality of water.

Chemical Disinfection

There are different types of bacteria, enteric viruses and protozoa, which are dangerous to exist in water, as they cause the diseases like, typhoid fever, cholera, gastro-enteritis, heart enamolies and so many other diseases. Disinfection of these may be performed by dosing the drinking water streams with chlorine, O_3, and Cl_2O, as higher the oxidation potential higher is the disinfection. The order of disinfection power by various reagents is given below

$O_3 > Cl_2O > Cl_2 > Br_2 > I_2$

They kill bacteria, reduce the slime growth on filters and in sedimentation basis.

O_3 and Cl_2 also reduce filter water turbidity

There are some ill effects of disinfection also e.g.

(i) Cl_2 reacts with humic acid and low molecular weight organic compounds to form toxic chlorinated organics

(ii) O_3 forms aldehydes which are toxic in nature.

(iii) Cl_2O forms chlorate and chlorite, which are also toxic in nature.

Therefore a calculated amount of oxidisers are to be used to avoid the above ill effects

Recommendations

(i) To improve the water quality, different types of techniques should be used, keeping in view the type of constituents present. Only filtration is not the only solution as indicated in the previous pages Therefore all the systems must be considered.

(ii) Reverse osmosis units are recommended to be produced locally For that collaboration with firms, supplying such equipment in Pakistan, may be asked to provide technology of membranes and module making/ manufacturing in Pakistan. Initial investments may lead to large savings if Govt. supports I) research and development activity of membrane processes. ii) encourage the investors and provides funds to have R O. membrane module industry in Pakistan

(iii) Small units working on low pressures and brackish waters are easy to make. This activity may be started locally. Traditional water purification technology is already there

(iv) A combination of Ion-exchange RO and Filtration + distillation and other such combinations must be looked into before designing a water purification plant

(v) R.O-cum-tubewell systems to convert brackish water to potable water may be used to recover part of saline water pumped and energy.

(vi) The Baluchistan coastal areas, and many parts of Punjab, Sind and NWFP have underground brackish water, which can be purified using membrane techniques. It is recommended that proper attention be ginen to this.

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SEPARATION AND SPECIATION OF ORGANO-PHOSPHORUS PESTICIDES BASED ON HYDROLYSIS USING REVERSE PHASE HPLC

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ABSTRACT: A new method for separation and speciation of organophosphorus pesticides has been investigated using reverse phase HPLC Pesticides are hydrolyzed by the addition of sodium ethoxide, the organic layer is separated from the aqueous phase which contain the acidic hydrolyzed portion of the respective pesticides Different pesticides give different acidic products on hydrolysis leading to variation in the retention time The hydrolyzed products are injected and separated on reverse phase HPLC Identification and quantification is done by running the respective standards

Introduction

Organophosphorus pesticides vary in toxicity and half lives Due to their excessive use in recent years their determination in water bodies has become very important This necessitated the determination of total pesticides on one hand and identification of specific organophosphorus pesticides on the other. Organophosphorus pesticides can be determined as a whole group by HPLC, gas chromatographic and thin layer chromatographic methods[1-8] Alternately phosphorus can be determined after decomposition or hydrolysis by Spectrophotometric methods[9-13]. Moreover the non-phosphorus group after hydrolysis can also be determined spectrophotometrically by a reaction depending on some properties of the non-phosphorus group[14-17]. Non-phosphorus methods can often be made specific for a single pesticide, or atleast for a group of related pesticides Such specific methods are of advantage if one of several pesticides in a sample needs to be determined. In this paper a new HPLC method capable of speciation and determination of organophosphorus pesticides based on hydrolysis is presented. This could be used for a quality check and certification of the drinking water sources with respect to contamination originating from an excessive use of the fertilizers.

Experimental

Instrument

HPLC system consisted of a Bacharach Coleman Tri Det with a pecosphere 3x3 C18 cartridge column, Perkin Elmer 100 series pump, recorder and thermostated water bath were used during this investigation.

Reagents

p-nitrophenol, fumaric acid, carbontetra-chloride, sodium metal, ethanol and methanol of A R. grade and commercially available pesticides were used without further purification.

Solutions

(1) p-nitrophenol (1000 ppm) solution·
Stock solution of p-nitrophenol was prepared by dissolving 0 1 g of the reagent in distilled water and diluting upto 100 ml in a volumetric flask.

(2) Fumaric acid (1000 ppm) solution·
Stock solution of fumaric acid was prepared by dissolving 0.1 g of fumaric acid in distilled water and diluted upto 100 ml in a volumetric flask.

(3) Sodium ethoxide (1%) solution:
1% solution of sodium ethoxide was prepared by dissolving 1 g of sodium metal in ethanol and diluted upto 100 ml

(4) Mobile Phase.
Water Methanol mobile phase was prepared in 1:1 ratio and degassed by bubbling N_2 gas through the solution for about 10 minutes

Procedure

Pesticide sample (0 1 ml) was taken in three separate separatory funnels, 6 ml of 1% sodium ethoxide, 5 ml of water and 5 ml of carbontetra chloride were then added to each separatory funnel. The resulting solutions were mixed well using a shaker for two minutes and transferred to respective beakers. The resulting solutions in beakers were heated on water bath for 15 minutes at 60°C. The aqueous phase was separated from organic phase using separating funnel The organic phase was retained for analysis by HPLC using reverse phase chromatography.

Results and Discussions

Separation of pesticides is one of the key requirements for assessing the toxicity of a particular pesticide in the environment. Total organophosphorus pesticides can be determined by molybdenum blue method while sulphur containing pesticides could be determined by methylene blue method In the present work HPLC method was exploited for the speciation and determination of organophosphorus pesticides The general structure of the organophosphate pesticides may be represented as

Where R_1 and R_2 are methyl or ethyl groups and X is an organic radical. The R_1 and R_2 substituent groups are less easily hydrolyzed from the phosphorus than is the X group. In the hydrolysis methods the pesticide is hydrolyzed with alkali to break the P-O(S)-X link, and then the liberated organic substituent is isolated and determined.

On hydrolysis methyl parathion give rise to the following products O, O-dimethylthiophosphate and p-nitrophenol

Similarly malathion was hydrolyzed into O, O-dimethydithiophosphate and fumarate as given below

Conditions were optimized for the separation and identification of p-nitrophenol and fumaric acid using reverse phase HPLC with UV detector (254 nm) on a pecosphere C18 cartridge column Water: Methanol (1 1) was chosen as the optimum mobile phase with a flow rate of 1 0 ml/min. The identification of the components was made both by following the retention time and the spiking method data. As different pesticides leads to different hydrolyzed products leading to variation and this property was exploited for speciation in mixture. The retention time of fumaric acid and p-nitrophenol was found to be 0 2 and 0 6 minutes respectively Working standards of fumaric acid and p-nitrophenol were injected in the range of 10-50 ppm, wherein the detection limits for p-nitrophenol and fumaric acid were found to be 3 0 ppm for both with 10μl injection volume The organic phase of the hydrolyzed product of methyl parathion and malathion were similarly injected (10μl) The active ingredients in the commercial products of these pesticides were calculated from the peak height of their organic hydrolyzed products using the respective calibration plots. The results are given in Table-1 As can be seen from this table that the concentration of pesticides in these commercially available pesticides are lower than the label value

Table 1 *Determination of Active Ingredients In Pesticides Using Reverse Phase HPLC*

Pesticide	**Active Ingredient (g / ml)**	
	Found	**Label Value**
Methyl Parathion	0 156	0 5
Malathion	0 196	0 5

Conclusion

Different pesticides lead to different products after hydrolysis Pesticides could be identified as well as quantified based on the retention time and peak height data of the hydrolyzed products of the specific pesticide Speciation studies for malathion and methyl parathion were conducted exploiting this technique using reverse phase HPLC with water-methanol as mobile phase and UV detection. After optimization of mobile phase and the retention time these pesticides were determined in different pesticide formulations The method is fairly simple, economical and compare well in term of detection limit (30 ng) with the other standard established gas chromatographic methods

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DRINKING WATER QUALITY MONITORING IN THE RURAL AREAS OF RAWALPINDI

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ABSTRACT. A case study to investigate the status of drinking water quality was conducted in the rural areas of Rawalpindi district covering Gujar Khan Kahuta, Murree, Rawalpindi and Taxila Tehsil For this purpose, water samples were collected and analyzed for about 24 water quality parameters including physico-chemical, inorganic constituents, trace elements and bacterial indicators Drinking water quality profile of the survey area where the parameter exceeds the WHO guidelines are prepared and health effects are also highlighted Most of water samples are not found fit for drinking purposes due to presence of coliform and E coli, Nitrate, Iron and Sodium are found in high concentration in some water samples This study demands the due attention of our policy makers and agencies responsible of drinking water schemes for the provision of safe drinking water especially in the rural areas

Introduction

The rapidly increasing pressure on available water resources from agricultural as well as domestic section, less attention is being paid to water quality As a result, water quality is deteriorating day by day and its consequent impacts are becoming permanent in shape and deteriorating human health in domestic sector and stagnant even degradation of agricultural yields This water is the key to future of life sustainability and economic development

Most of the communicable diseases are water borne and those diseases cause morbidity and mortality. In Pakistan, despite of the high mortality rate specially in the infants due to unsafe drinking water, no attention is being given to the drinking water quality improvements. Neither the public nor the decision maker are well aware of the gravity of the drinking water situation However, in some places some remedial measures such as filtration and chlorination have been taken but these are quite in-sufficient and in efficient and confined only in major urban areas covering 32% population of the country The remaining 68% of the rural population is drinking water of poor quality. Awareness among the masses about the safe drinking water is to be propagated The poverty, low education rate, political instability, socio-cultural problems and low priority to enhance safe water supply coverage to masses are major factors.

The water supply systems in most of the cities, towns and villages carries numerous injurious bacteria and other pollutants. Some of the contamination are due to the geological structure of the area bearing un-healthy minerals affecting the taste and characteristics of water. Some examples of these minerals are chloride. lime, magnesium, lead, chromium and zinc etc The composition of water varies widely in its main inorganic constituents which are sodium, potassium, calcium barium, iron, zinc, bicarbonate, chloride, sulphate, phosphate and nitrate. Organic compounds like pesticides, detergents, lindane 2, 4-D, phenolic substances and carboxylic acids can also cause water pollution.

The news in respect of water borne diseases were become common feature in the daily news papers circulated in twin cities of Rawalpindi and Islamabad It has been reported in the English Newspapers that about 200 children as well as 40 to 50 adult patients suffering of water borne diseases being admitted daily to Rawalpindi hospitals, The patients suffering from such diseases mostly belonged to surrounding rural areas of Rawalpindi. Diseases like jaundice, gastro-enteritis (stomach diseases), diarrhea and typhoid are on the rise due to the consumption of unhygienic water and mixing of potable water with the sewerage water Some of those patients were brought to hospitals in serious condition and admitted to intensive care units (ICU) Children easily fell victim to such diseases, they generally used contaminated water and suffered from lack of proper care To arrest the severity and to know the causes of problem, the drinking water quality monitoring study has been conducted of Rawalpindi rural areas covering five Tehsil i.e Gujar Khan, Kahuta, Murree, Rawalpindi and Taxila This research study was confined to assess the existing water quality status and to suggest remedial measures for the improvement of drinking water quality on the basis of research findings.

Methodology

Total number of 29, 19, 23, 19 and 26 water samples were collected randomly from Tehsil of Gujar Khan, Kahuta, Murree, Rawalpindi and Taxila respectively About 24 water quality parameters were determined to identify the pollution problems i e. harness, alkalinity, aluminium, sodium, calcium,, chloride, nitrate, conductivity, colour, copper,. free carbondioxide, magnesium, pH, phosphate, potassium, taste, total dissolved solids, iron, zinc and manganese contents, E. coli, coliform and non coliform and the water quality parameters compared with WHO standards to differentiate the polluted and non polluted water samples the coliform bacteria are detected by their ability to ferment lactose in culture at 35°C or 37°C The collected samples were brought to the PCRWR, laboratory within the shortest possible time for reliable analysis. Some preliminary physico-chemical observations were recorded at site by using field equipment and water pollution kit Standard analytical procedures and methods were adopted

Results and Discussions

The topographical characteristics and water sources of the study area from where the water samples were collected are given at Table 1 The people of the study area usually fulfill their domestic and drinking water requirements by collecting water from nearby wells, tubule wells, ponds, water supply schemes, hand pumps, springs etc. It was observed during the water sampling that the close and covered water supplying systems were discharging more clean and transparent water than he open air systems

The Table 2 is depicting the mean values of water quality parameters determined and then overall assessment of the water quality found in the study area is drawn wherever the extreme concentration / level of any parameter was observed the same has been elaborated in the text

In some area situation of water quality was very inferior, alarming and unbelievable The two examples are given to show the picture regarding hygienic supply of water to the rural population.

The village Dukhi Dukhli Begum in Tehsil Gujar Khan where uncovered ponds are being used as a source of drinking water for human and livestock The water contains growth of coliform, non coliform and E coli.

The village Gorakhpur (Udiala) in Tehsil Rawalpindi has higher nitrate contents i e. 63 3mg/l than the permissible limits of WHO (10mg/l) Excess nitrate in water is harmful for human health especially to the kids; causes blue baby disease, infantile methemoglobinemia and death Changes of Nitrate (NO_3) into Nitrite (NO_2) in human mouth or gut and forms-N- Nitosamine, a suspect carcinogen

The date compared with WHO standards and a number of pollutions were identified. Water quality parameters having desirable values are collectively discussed

Desirable Water Quality Parameters

About 24 water quality parameters were analyzed to identify the pollution problems Water samples were found to be fit with respect to alkalinity, aluminum, calcium, chloride, conductivity, colour, copper, free carbondioxide, magnesium, pH, phosphate, potassium, taste, total dissolved solids and zinc contents. The values of iron were found within the desirable level in the water samples of Gujar Khan, Kahuta, Rawalpindi and Taxila In samples of Rawalpindi and Murree the quantity of manganese was present in most cases under the desirable limits The water samples collected from Murree and Rawalpindi Tehsil were found safe in respect of nitrate WHO has given 250 mg/l and 200 mg/l a highest desirable levels for chloride contents and sodium respectively As per the limits, only 2 samples in respect of chloride contents and 7 samples having sodium more than WHO standards however, water samples of other Tehsil were within the limits in respect of chloride contents and sodium.

Undesirable Water Quality Parameters

The drinking water quality parameters were found above the highest desirable level of WHO standards are hardness, nitrate (N), chloride, iron and sodium, Most of the tested water samples have normal concentrations of chloride, iron and sodium in Kahuta, Rawalpindi and Taxila. However, 10.3% and 20 7% samples have more chloride and sodium respectively in Gujar Khan, and Murree, 34 8% samples have more iron than that water quality standards The mean values and ranges are shown in Table 3 The results are discussed below.

(i) Hardness

Although the mean values of hardness in water samples of Gujar Khan, Kahuta, Murree, Rawalpindi and Taxila are found less than the WHO highest desirable level (500 mg/l of hardness as $CaCO_3$) 352 8, 440.8,335 8, 320 and 406.7 mg/l respectively, nevertheless about 14% 26% 4% 10% and 11% water samples collected from Gujar Khan (125 to 825 mg/l), Kahuta (250 to 762 mg/l), Murree (74 to 537 mg/l), Rawalpindi (58 to 687 mg/l and Taxila (262 to 525 mg/l) were possessing high values than WHO standards The literature has indicated the reasons of high $CaCO_3$ in water which are i) Calcium and magnesium in the form of minerals and lime stones + chalk ($CaCO_3$) are present in soils and ultimately in water, ii) Industrial products as well as polyvalent ions of zinc, manganese, aluminum, strontium, barium, iron are responsible for hardness

The presence of high contents of $CaCO_3$ in water leads to an increased incidence of urolithiasis and possess laxative properties due to association of magnesium with the sulphate ions. A number of studies have demonstrated significant negative association between water hardness and cardiovascular diseases. Other diseases like certain nervous system defects, anencephaly, prenatal mortality and various types of cancer are correlated with hardness of water The hard water has been reported the main causes of house hold pipes choking with deposited scale, encrustation on kitchen utensils and increasing soap consumption A hardness level of about 100 mg as $CaCO_3$ per liter provides an acceptable balance between corrosion and encrustation.

(ii) Nitrate (N)

The mean concentrations of nitrate nitrogen (mg/l) in water samples was found more than WHO standards (10 mg/l) in study area viz Gujar Khan (11 4), Kahuta (17.7), Rawalpindi (17 5) and Taxila (8 67). A reasonable %age of water samples are not fit for drinking purpose in Gujar Khan (24%),

Table 1 *Topographical characteristics and water sources of the study area*

S.No	Tehsil	Source	Topography
1	Gujar Khan	Well, Tube well, hand Pump, Water Supply, Pond	Plain & Semi Hilly
2	Murree	Spring, Well, Water Supply	Hilly area
3	Kahuta	Well, Hand Pump, Water Supply, Spring	Hilly area
4	Taxila	Well, Tube well, Spring	Plain & Semi Hilly
5	Rawalpindi	Well, Tube well, Hand Pump, Water Supply	-do-

Table 2. *Intensity of pollution found in water samples collected from the study area*

Water Quality Parameters	WHO Standards mg/l	Gujar Khan		Kahuta		Murree		Rawalpindi		Taxila	
		*	**	*	**	*	**	*	**	*	**
Hardness	500	4	13 8	5	26 3	1	4 3	2	10 5	3	11 5
Nitrate (N)	10	7	24 1	5	26 3	-	-	-	-	3	11 5
Chloride	250	3	10 3	-	-	-	-	-	-	-	-
Iron	0 3	-	-	-	-	8	34 8	-	-	-	-
Sodium	200	5	17 2	-	-	-	-	2	10 5	-	-
E Coli	-	19	65 5	16	84 2	17	73 9	13	68 4	14	53 8
Coliform	-	25	86 2	15	78 9	20	87	17	89 5	20	76 9
Non-Coli	-	25	86 2	17	89 5	20	87	17	89 5	19	73 1
Total No of samples		29		19		23		19		26	

* Number of polluted samples, ** Percentage of polluted samples

Table 3 *The Concentration of NO_3 (N), Cl, Na & Fe in water samples of study area*

Main Study Site/Range	Sampling Sites	Water Source	Conc (mg/l)	Parameter
Gujar Khan (0 3-72 2)	Mera Shams	Well	12 7	NO_3 (N)
	Mohra Bhatian	Well	13 0	-do-
	Galyana	Well	42 5	-do-
	Chak Dolat	Well	48 6	-do-
	Gohra	Well	72 2	-do-
	Ranjali	T Well	10 7	-do-
	Phadana	Well	269	Cl
	Syed Adda	Well	1540	-do-
	Manghot	Well	513	-do-
	Galyana	Well	360	Na
	Syed Adda	Well	1520	-do-
	Manghot	Well	420	-do-
	Jajjah	Well	246	-do-
	Gorha	Well	354	-do-
Kahuta (0 2-111)	Police Station	W Supply	108	NO_3 (N)
	Kalar Sydan	Well	25 4	-do-
	Phakrhal	Well	52 1	-do-
	Chani Bazar	Well	111	-do-
	FG Boys School Dalla	Well	13 3	-do-
Rawalpindi (0 25-92 1)	Mara Mohra	Well	26	NO_3 (N)
	Mudhal	Well	13	-do-
	Jinnah Town Adyala G School	Well	92 1	-do-
	Gorakhpur New Lala Zar	Well	63 6	-do-
	Mara Mohra	Well	61 2	-do-
	Dhok Badhal	Well	202	-do-
		Well	230	-do-
Taxila (0 1-17 8)	Umrial	Well	11 2	NO_3(N)
	Thatta Khalil	Well	71 8	-do-
	Pind Nowshehri Khan	Well	61	-do-
	Chowkar	Well	19 5	-do-
Murree	Romal Village	Spring	0 37	Fe
	Gheka Gali	Spring	0 36	-do-
	Aliot	Spring	0 32	-do-
	Patriata	Spring	0 32	-do-
	Abbasi Hotal L Topa	Spring	0 39	-do-
	Ghurial Gheka Gali	Spring	0 37	-do-
	Bansera Gali	Spring	0 35	-do-
	Gorha Gali	Spring	0 36	-do-

Kahuta (26%) and Rawalpindi (11%) due to high concentrations of nitrate nitrogen (Table-3). The chemical fertilizers, decay of vegetable and animal matter, domestic effluents, sewage sludge, industrial discharges, leachates from refuse dumps and atmospheric washout are considered the main contributors of nitrate (N) in water sources Higher levels of nitrate are found in ground water as compared to surface water. High levels of nitrate (N) are responsible for cause of infantile methemoglobinemia (30-40% lead to anoxia) and ultimate death Infants may suffer from gastro intestinal disturbances The pregnant women are at greater risk than the general adult population.

(iii) Sodium

The NaCl salt is found in rocks (rocksal), silicate minerals, amphiboles and feldspars, sea water and it is present about 26 g/kg of the earth's crust. Sodium salts are added in water system from the washing of salt affected soils, domestic and sewerage used water and industries of glass, soap, leather, pharmaceutical, chemical, treatment plants, ice and ice cream making, food industry Excessive intake of sodium chloride causes vomiting, convulsions, muscular twisting, rigidity, cerebral and pulmonary oedema, deterioration of chronic congestive heart failure, hypeertension and ill effects have also been documented. Fresh fruits and vegetable contain from 10 mg to 1 g/kg of NaCl. Milk contains a relatively high proportion of sodium chloride i e 1 5 g/kg The minimum NaCl requirement is about 120 mg/day WHO has recommended 200 mg/l as a guideline value

(iv) Chloride

It is distributed in the form of NaCl, KCl, $CaCl_2$, salts in the soil and Water bodies, Effluents of chemical industries, oil well operation, sewage discharge, irrigation drainage, refuse leachates and sea water intrusion in coastal areas are the major factors of chloride addition in water The Chloride is essential as about 530 mg of NaCl salts per day are excreted from the adult human body It is estimated that more than 9 mg of Cl per kg of body weight is needed. The taste threshold levels for NaCl, KCl, $CaCl_2$ in water are 210, 310,222 mg/l. Approx. 600 mg. of chloride per day are ingested in a salt free diet. An average intake from drinking water is approx 100 mg/day.

(v) Iron

The Iron in water is present in the ferric (Fe^{+3}) state. It is added in water from rocks, minerals, acid mine drainage, iron related industries The Fe is essential in human nutrition for body infrastructures (bones) and nervous system and daily requirement is 7-14 mg. The higher intake results hemochromatosis Ferrous salts are unstable and precipitate as insoluble ferric hydro-oxide, which settles out as a rust coloured layer, such water often taste unpalatable, stains laundry and plumbering fixtures WHO has recommended 0 3 mg/l as a guideline value

Study Area	Coliform (%)	N Coliform (%)
Gujar Khan	86 2	86.2
Kahuta	78.9	89 5
Murree	87 0	87.0
Rawalpindi	89.5	89.5
Taxila	73 1	73.1

This study indicates clearly that the drinking water being supplied by water supply schemes and used by rural population of Rawalpindi district area is not safe for drinking purpose

Measures for Safe Drinking Water

A number of measures have been proposed for provision of safe and pure drinking water to population of rural areas i) The contamination of water drawn from wells, ponds hand and other pumps etc., is very common due to presence of nearby septic tanks and pit latrines in the rural areas The problem needs to be studied in detail to arrive at appropriate designs of the whole system in order to get contamination free drinking water ii) The biological contamination can be controlled by simple chlorination. The water supplied by regular schemes must be chlorinated before its discharge into the main supply system Chlorine may be added to drinking water supplies to destroy harmful bacteria Potassium permanganate and bleaching powder may also be used for the sterilizing of well or pond waters All domestic underground and over head tanks should be cleaned periodically iii) The new water supply schemes may be approved and implemented only after investigation of water quality. The Govt. must initiate safe water supply schemes in rural areas where chemical contamination's are in excess like iron, manganese, Nitrate, etc the alternate sources of water may be searched out by using Resistivity survey techniques. iv) In-house water filters such as Ceramic Water Filter using silver coated sand may be used for water decontamination and removal of dust, silt etc v) To set up guideline values continuous research and monitoring National water quality standards strictly by enforced vi) Low cost water treatment technologies be introduced for treating water supply in rural areas. vii) The people to be educated on such techniques through mass contact by using mosque media, radio, television and other means of mass communication.

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SYNTHETIC INORGANIC ION-EXCHANGERS: EFFICIENT SCAVENGERS FOR TOXIC POLLUTANTS IN WATER

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ABSTRACT Synthetic inorganic ion-exchangers are easy to prepare, stable towards heat and ionizing radiations, resistant to chemicals and have convenient properties as compared to their commercial organic counterpart They include hydrated metal oxides, acidic salts of polyvalent metals i e phosphates, arsenates, molybdates, tungstates, antimonates, selenites and vanadates, salts of heteropolyacids such as phosphomolybdates, tungstoarsenates, phosphosilicates, insoluble Ferro and ferricyanides, sulphides and alkaline earth sulphates

They have been found to be very selective and efficient scavengers for the removal of toxic metal ions and organic pollutants present in water They have been discussed in detail giving specific examples where they can be successfully utilized for the purification and decontamination of water

Introduction

Synthetic ion-exchangers are superior to their commercial organic counterparts due to their easy preparation and low cost, stability towards heat and ionizing radiation, resistance to acids, bases, organic solvents, oxidizing and reducing reagents and capacity over a wide range of acidity[1] Because of their convenient chemical properties selectivity and efficiency, they have been extensively used in last four decades in Analytical Chemistry, Radiochemistry, Environmental Chemistry, Nuclear Technology, Hydrometallurgy and in metal recovery, water purification and decontamination, and in nuclear and industrial waste management[2]

Applications of Inorganic Ion Exchangers

They have been utilized for the separation preconcentration of analyte element in order to remove interferences or impurities and to achieve its detection limits before its actual measurement if its concentration is below the detection limit of that particular analytical method to be used Moreover, these ion-exchangers have been employed to have carrier-free production of radioisotopes as generators. They have been applied to achieve the decontamination of coolant water in a reactor at high temperature and pressure They are useful in the removal of radioactivity or radionuclides present in large volumes of water or to achieve decontamination of vast area of floors They have also been employed successfully for water purification and decontamination They have also been used for the desalination of highly saline water They have been used to process fresh and highly radioactive fuel They have useful applications in the treatment and safe disposal of nuclear and industrial liquid waste into waterways They have been utilized for the purification and isolation of transuranic elements from highly radioactive fission products in the spent nuclear fuel[2]

Classification of Ion-Exchangers

The inorganic ion-exchangers include hydrous and non-hydrous metal oxides, acid salts of polyvalent elements i e phosphates, arsenates, molybdates, tungtates, antimonates, selenites and vanadates, salts of heteropolyacids like phosphomolybdates, tungstoarsenates, phosphosilicates, insoluble ferro and ferric-yanides, sulphides, and alkaline earth sulphates Some typical inorganic ion-exchangers which have been used are listed in Table 1

Table 1. *Synthetic Ion - Exchangers*

Antimonates Ti Cr Sn Ce, Ta	Selenites Ti, Sn
Arsenates Ti, Zr Sn	Sulphides Fe, Cu, Ni, Zn, As, Ag, Cd, Hg, Pb
Ferrocyanides Ti, Mn, Fe, Co, Ni, Cu, Zn, Zr Mo, Ag, Cd, W, Pb, Bi, U	Sulphates Ca, Sr, Ba
Molybdates Ti, Cr, Zn, Sn	Tungstates Ti, Cr, Ce
MOLYBDOPHOSPHATES Li, NH4, Na, K	Tungstophosphates Li, NH_4, Na, K
Oxides Mg, Al, Si, Ti, V, Cr, Mn, Fe, Zn, Zr, Nb, Mo, Ag, Sn, Sb, Ta, W, Pb, Th	Vanadates Al
Phosphates Ti, Cr, Zr, Sn, Ta	

Essential and Toxic Elements

For biological systems including plant and animal life the elements can be classified into two categories i e essential and non-essential elements. The essential elements perform essential role in a living organism and their deficiency consistently results in the impairment of a function from optimal to suboptimal level The essential element is present in all healthy tissues of all living things Its withdrawal from the body induces some structural and physiological abnormalities, its addition either removes or prevent these abnormalities. The abnormalities due to their deficiency always accompany pertinent and specific biochemical changes and these changes can be cured or prevented when this deficiency is removed[3] Another group of elements is known as toxic because their biological significance is confined to their toxic or potentially toxic properties at relatively low concentrations All trace elements are toxic if ingested or inhaled at sufficiently high levels for long enough periods Continued ingestion of diet or continued exposure to total environment that are excessively high in a particular toxic element induce changes in the functioning, forms, activities or concentration of that element in the body tissues and fluids so that they rise above the permissible limits In these circumstances biochemical defects develop, physiological functions are affected and structural disorders rise in ways which differ with different elements with the degree and duration of toxicity and with the age, sex and species of the animals involved [4] An element is said to be toxic if it injures in the growth or metabolism when supplied above certain concentration. Toxicity is due to the binding at non-binding centers or precipitation of a metal of the metalloenzymes and by the replacement of essential elements in the molecules or enzymes. However, many clinical and pathological disorders in the animals as a consequence of the toxic elements excess cannot be explained in biochemical or enzymatic term. Their toxicity above certain concentration level for biological systems has been proved. These elements are Be, Hg, Pb, Cd, Cr, As, Sb, Se, Ti, U, Th and Pu Chromium selenium and arsenic are among essential trace elements However, their deleterious effects and toxicity on biological systems have been proved in many instances.

Sources of Toxic Elements

The major sources of toxic elements and their compounds are listed [5] in Table-2 Because these toxic elements are harmful, their tolerance limits in air, food and water have been identified Table-3 gives the tolerance limits of these elements in drinking water [6] and their concentration ranges measured in fresh water[7] are very low as compared to their tolerance limits in drinking water except in case of lead where higher concentration of lead found in fresh water is quite close to its tolerance limit in drinking water.

Table 2 *Major Sources of Toxic Elements and their Compounds*

Be	Alloys, Ceramic and Refractory Products, Rocket Fuel, X-Ray Tubes, Electronic Industry
Cr	Stainless Steel, Chrome Plating, Non-Ferrous Alloys, Leather Tanning, Printing, Dyes, Pigments, Paints, Refractories, Wood Preservatives, Welding, Batteries, Catalysis
As	Laser and Solid State Devices, Herbicides, Wood Preservatives, Medicinal And Veterinary Uses, Bottle Glass, Alloys Pigments, Textitle Printing, Taxidermy
Se	Laser Technology, Xerography, Infrared Photography, Photoelectric And Solar Cells, Storage Batteries Rectifiers, Glass and Ceramic Industries, Pigments,Rubber, Lubricating Oils And Greases, Drugs and Special Medicines
Cd	Electroplating, Pigments, Storage Batteries, Rubber, Paints, Plastics, Pigments, Semiconductors, Brazing and Low-Melting Alloys, Welding, Fungicides and Insecticides, Reactor Control Rods
Sb	Special Alloys, Pigments, Paints, Small Arms and Bullets, Storage Batteries, Semiconductors, Electronic Devices, Medicines, Cable Sheathing, Flame-Proofing Compounds, Glass and Pottery, Linotyping
Hg	Fungicides, Dental Preparations, Electrical Apparatus, Industrial Control Instruments Dry Batteries, Paints, Pharmaceuticals, Explosives, Metal Plating
Tl	Corrosion Resistance Alloys, Electronic Equipment, Photoelectric Cells, Optical Systems, Fiberglass, Rodenticides, Insecticides
Pb	Gasoline Additives, Ammunition, Metal Products, Paints, Pigments, Storage Batteries, Glass Making, Plastics
Th	Nuclear Fuel, Gas Mantles
U	Nuclear Fuel, Research, Ceramic Glazes, Alloys
Pu	Nuclear Fuel

Table 3 *Tolerance Limits of Toxic Elements in Drinking Water and their Concentration in Fresh Water*

Element	Tolerance limits[6] $\mu g\ L^{-1}$	Fresh water concentration[7] $\mu g\ L^{-1}$
Be	-	0 01 - 1
Cr	50	0 1 - 6
As	20 - 50	0 2 - 230
Se	10	0 02 - 1
Cd	5 - 10	0 01 - 3
Sb	10 - 23	0 01 - 5
Hg	1	0 0001 - 2 8
Tl	-	-
Pb	50 - 100	0 06 - 120
Th	-	-
U	1 2	0 02 - 5
Pu	-	-

Factors Controlling Sorption

The inorganic ion-exchangers due to their superiority over commercially available ion-exchangers have been used for the removal of toxic metal ions present at low concentrations The sorption behaviour of these metal ions from different electrolytes under experimental conditions can be exploited to achieve this goal The sorption of metal ions onto inorganic ion-exchangers depends on many factors[8] such as nature and composition of electrolyte, its pH, temperature, equilibration time between sorbent and sorbate, presence of complexing agents, anions and cations, ionic strength, aging of sorptive solution and sorbent and concentration of metal ions, surface area and other properties of sorbents. These parameters have to be optimized to achieve maximum sorption

Specific Examples of Sorption of Metal Ions

In Table 4 few specific examples from current literature are mentioned where inorganic ion-exchangers can be used for the removal of toxic elements from aqueous solutions In column 2 and 3 of this table sorption and desorption conditions have been enumerated For example U(VI), Cr(III) and Sb(V) are sorbed almost quantitatively[10] from buffer solution of pH[6] onto tin oxide surface whereas these metal ions can be desorbed using aqueous nitric acid solution Similarly, Cd(II) can be sorbed (> 99%) from its very dilute solution of

Table 4 *Ion-Exchangers as Scavengers for Toxic Elements*

Element	Ion Exchanger	Adsorption Conditions	Desorption Conditions	Ref
Cr(III) 10^{5} M	Iron Oxide	pH 6 5	-	9
UO_2^{2+}, Cr^{3+}, Sb^{5+}	Tin Oxide 50 ml / g	pH 6, 98 9%, 96 3%, 99 8% respectively	(HNO_3 H_2O) (1 3)	10
Cr(VI) 10^{5} - 10^{2} M	Vanadium Oxide 48 ml/g	pH 2, 90%		11
Cr (IV) 1-6 x 10^{4} M	Fe(III)/ Cr(III) Hydroxide	≤100% sorption pH 5 7	-	12
CD(II) 10^{5} M	Hydrous Ceric Oxide	92 1% from pH 10 47 solution	≥ 3%	13
SbO_3^{2}	Al_2O_3	99% 0 1M HNO_3	1 M NH_3	14
Hg (II) 1 5 x 10^{4} M	Manganese Dioxide	100% sorption at pH 6	100% d4esorption with 0 05 M EDTA solution	15
Pb(II) 10^{3} M	Ferric Oxide, Manganese Oxide, Aluminium Oxide 100 ml / 0 1 mg	pH 8 100%		16
Th(IV)	Manganese Dioxide 200 ml/250 mg	pH 8 7 98%		17
UO_2^{2+} 10^{4} M	Silica Gel-Titania mixed	100% pH 4-7 solution		18
Pu (IV)	Manganese Dioxide	pH 8 - 10, 90%		19
Se (IV) 7x10^{8}-7x10^{6} M	Titanium Oxide 4 5 ml/50 mg	0 01 M HCl, HNO_3, $HClO_4$ or H_2SO_4 ≥ 99%	-	20
Pb (II)	Stannic Phosphate	99 2% at pH 6 5	-	21
Cd(II) 10^{8} M	Sodium Titanate 100 mg/10 ml	99 2% from 10^{3} M HCl or H_2SO_4 or pH ≥ 4 5 solution	1M HCl or H_2SO_4	22
Hg (II) 10^{7} 10^{2} M	Potassium Titanate	97 4% from 0 1 M Oxalic Acid + 0 2 M NaCl, 97 2% at pH 6 5	-	23
Th (IV) 10^{5} - 10^{3} M	Strontium Sulphate	97 2% from 1 M NaCl + 0 1 M $H^{2}SO_4$	-	24
Tl(I), Cd(II), Pb (II) 5x10^{3} M	Chromium Ferrocyanide	98, 98, 92 6% pH 2-3	Tl(I) Desorbed with 3 M mixture of NH_4NO_3 + HNO_3	25

0 001 M HCl or H_2SO_4 onto sodium titanate[22] The sorbed cadmium can be removed from the surface using comparatively concentrated solution of 1 M HCl or H_2SO_4 These examples show that toxic elements can be removed from aqueous solutions using inorganic ion-exchangers effectively

Conclusions

It can be concluded that these ion-exchangers may be used for the decontamination or purification of water. They can be utilized to separate toxic elements from their very diluted solutions in water. They can also be employed for the removal of toxic elements from industrial effluents before their safe disposal into waterways.

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WATER CHEMISTRY, QUALITY CONTROL BY ELECTROCHEMICAL METHODS

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ABSTRACT. Water is very good solvent It dissolves most of the salts and substances which come in contact with it and its properties vary according to the solutes present in it Thus ionization of water, acid base equilibria, solubility constants, common ion effect, secondary salt effect, complexation, Redox process, corrosion processes, chemical kinetics, colloid and scale formation etc all depend on the solutes present in water Before carrying out any processes of water purification and treatment one has to take into consideration the properties of the solutes present and these can be well understood and explained by electrochemical methods Most of the work in water purification, water sterilization, coagulation, filtration, screening, sedimentation etc involves solution chemistry For quality control of water electrochemical techniques are sensitive, reliable, cost- effective and can analyse a large number of constituents of significant importance Metals and other toxic substances have been effectively removed by electro--deposition, electrodialysis and electro-oxidation from industrial waste water All types of pollutants from waste water can be effectively removed using electrochemical reactors In power plants scale formation and water corrosion are most important problems which are also electrochemical in nature

Introduction

Water is the most important constituents for human-life Without water life is not possible because of its essentiality for life God has provided this on earth globe in abudance Nearly three fourth of the earth globe consists of water Human populations have been concentrated in those areas where drinking water was available in abudance Natural waters are never completely pure. During there precipitation and their passage over or through the ground they acquire a wide variety of dissolved or suspended impurities This raw water must be treated and purified before using for industrial and drinking purposes[1] For proper treatment of water, water chemistry must be known, which means the different constituents present in water and their properties in solution[2] Due to industrialization a large number of pollutants have been added into water sources It is necessary to do proper quality control of drinking and industrial water for different constituents[3-6].

In this paper water chemistry is briefly described water purification and treatment have been mentioned and water quality control have been discussed It has been shown that electrochemical methods are simple, cost-effective, sensitive and reliable for all purposes

Experimental

VA processor 646 Potentiograph 536 and pH meter 605 all from Metrohm, Switzerland, Polarographic analyzer 174A Electrochemistry system370 from Princeton Applied Research, USA were used. Codonductivity meter used was from Wescan,USA.

All the chemicals used were of proanalysis grade from E-Merck, Germany

Trace metals were analysed using differential pulse anodic stripping voltammetry.Standard electrochemical methods were used for all the measurements.

Results and Discussions

Study about the behavior of different solutes present in water is called water chemistry and monitoring or analysis of different constituents in water is termed as quality control and there is third aspect known as water purification or treatment and for all of these three parameters electrochemical methods are most convenient, useful, reliable and above all cost- effective

Water Chemistry

Chemical substances of interest range from dissolved gases through inorganic salts and other compounds to complex organic materials, both natural and synthetic, washed from fields and forests and contained in municipal and industrial waste waters. Water chemistry refers to the chemical properties of aqueous solutions containing any of the wide variety of substances, found as impurities in natural waters, added to water during treatment, picked up in the flow of water or imposed upon water through domestic, municipal or industrial uses

Water ionizes into acid and basic radicals and thus can dissolve both types of substances i e; acid as well as basic

$$H_2O \Leftrightarrow H^+ + OH^-$$

$$2H_2O \Leftrightarrow H_3O^+ + OH^-$$

For acidic substances ionization constants may be given as

$$H_2CO_3 \Leftrightarrow H^+ + HCO_3^- \qquad K_1 = \frac{[H^+]\,[HCO^-_3]}{[H_2CO^-_3]}$$

$$HCO_3 \Leftrightarrow H^+ + CO_3^{--} \qquad K_2 = \frac{[H^+][CO_3^{--}]}{[HCO_3]}$$

For basic compounds ionization constants are

$$NH_3 + H_2O \Leftrightarrow NH_4^+ + OH^- \quad K = \frac{[NH_4][OH^-]}{[NH_3]}$$

Alkalinity of water is of paramount importance both for drinking and industrial purposes. It may be bicarbonate, carbonate or hydroxide alkalinity.

These can be calculated by simple method

P = Phenolphthaline alkalinity

T = Total alkalinity

a = P/T

If a = 0, bicarbonate alkalinity = T

If a < 0.5 = (1-2a)T

Carbonate alkalinity = 2aT

If a = 0.5 = T

If a> 0.5 = 2(1-a)T

Hydroxide alkalinity = (2a-1)T

If a = 1 = T

Solubility constants (Pks) of some compounds used in water treatment alongwith their applications are important. Pks of $Al(OH)_3$ and $Ca(OH)_3$ are 32.9 and 5.26 which are used for coagulation and softening respectively [7]

Stability constants of hydroxocomplexes used for water treatment are also important. Both solubility constants and stability constants can be calculated by electrochemical methods.

Dechlorination, deoxygenation, inorganic biochemical metabolism have specific potentials (Table.1). Oxidation related to disinffection and odour control are also potential and pH dependent (Table-2) Water corrosion is also properly explained and understood by electrochemical methods (Table-3).

Water Treatment

Major problem in water treatment is removal of colloidal particles. Colloidal particles as a result of their small size have a very large ratio of surface area to volume. For example 1 Cm^3 of material if divided into cubes 0.1mm on a side will have a surface area of 0 06 m^2, while if divided into cubes 10^{-5} mm on a side will have surface area of $600m^2$. Colloidal particles may be even smaller than 10^{-5}mm Most colloidal particles in water and waste water are negatively charged. The stationary charged layer on the surface is surrounded by a bound layer of water in which ions of opposite charges drawn from bulk solution produce a rapid drop in potential. This drop within the bound water layer is called the stern potential, a more gradual drop, called the zeta potential occurs between the shear surface of the bound water layer and the point of electroneutrality in the solution. Stability of colloids depends on the magnitude of the zeta potential. Coagulation is a chemical technique directed towards destabilization of colloidal particles by using polyelectrolytes.

Sterilization/ Disinfection of water is mostly done by using chlorine and this chlorine is produced by the electrochemical decomposition of brine.

Quality Control

Electrochemical methods are frequently used for the quality control of drinking and industrial water. Mostly used electrochemical methods are potentiometry, ion-selective electrodes, conductometry, polarography, voltammetry, stripping voltammetry and coulometry.

Potentiometry

In this technique change in potential is measured for the determination of different constituents A large number of constituents can be measured using this technique Some of the important constituents which are measured in water by this technique are; pH, alkalinity, acidity, Aluminium, Silver, Amino compounds, acetic acid, gold, bromine, boric acid, chloride, ClO_3, ClO_4, cyanide, copper, calcium carbonate, carbonyl compounds, carboxyl acids, cerium, calcium, phosphate, EDTA, NTA, Mercury, Nickel and many others.

Table: 1: *Dechlorination, Deoxygenation, Inorganic Biochemical Metabolism*

S.No.	Reaction	E^0V	Remarks
1	$SO_4^{--} + 4H^+ + 2e = H_2SO_3 + H_2O$	0 172	Dechlorination,deoxygenation (←)
2	$SO_4^{--} + 8H^+ + 6e = S + 4H_2O$	0 375	Bacterial Reduction (←)(-0 21 at pH 7)
3	$S + 2H^+ + 2e = H_2S$	0 142	Sulfer bacteria (→)-0 33 at pH 7
4	$HNO_2 + 7H^+ + 6e = NH_4^+ + 2H_2O$	0 86	Nitrification(←)0 38 at pH 7
5	$NO_3^- + H_2O + 2e = NO_2^- + 2OH^-$	0 01	Nitrification (←) at pH 7

Table 2. *Oxidation Related to Disinfection and Odour Control*

S No.	Reaction	E^0V	Remarks
1	$O_3 + 2H^+ + 2e = O_2 + H_2O$	2 07	Most powerful (→)1 68 at pH 7
2	$H_2O_2 + 2H^+ + 2e = 2H_2O$	1 77	1 26 at pH 7 (→)
3	$MnO_4^- + 4H^+ + 3e = MnO_2 + 2H_2O$	1 68	Odor oxidation (→) 1 13 at pH 7
4	$HOCl + H^+ + 2e = Cl^- + H_2O$	1 49	1 28 at pH 7 (→)
5	$Cl_2 + 2e = 2Cl$	1 358	(→)
6	$ClO_2 + e = ClO_2^-$	1 15	$ClO_2 < HOCl$ (→)
7	$Br_2 + 2e = 2Br^-$	1 087	
8	$OCl^- + 2H_2O + 2e = Cl^- + 2OH^-$	0 88	OCl^- oxidation (→) at pH 14

Table 3 *Metallic Corrosion and Cathodic Protection*

S.No.	Reaction	E^0V	Remarks
1	$Mg^{++}+2e = Mg$	-2 37	Sacrificial anode (←)
2	$Al^{+++}+3e = Al$	-1 67	Sacrificial anode (←)
3	$Zn^{+++}+2e = Zn$	-0 762	Sacrificial anode (←)
4	$Fe^{++}+2e = Fe$	-0 409	Initial corrosion (←)
5	$Pb^{++}+2e = Pb$	-0 126	Initial corrosion (←)
6	$Cu^{++}+2e = Cu$	0 345	Initial corrosion (←)
7	$Fe^{+++}+e = Fe^{++}$	0 771	Ferous oxidation (←)
8	$Fe(OH)_3+e = Fe(OH)_2+OH^-$	-0 56	Rust formation (←)

Ion-selective Electrodes

These are electrodes prepared for the measurement of specific constituents. A large number of ion- selective electrodes are available in market. Some of the commonly used ion- selective electrodes are Aluminium, Ammonia, barium, bromide, cadmium, calcium, carbon dioxide, chloride, cobalt, copper, cyanide, fluoride, fluoroborate, iodide, lead, lithium, magnesium, manganese, mercury, molybdate, nickel, nitrate, nitrite, perchlorate, phosphate, potassium, selenium, silver, sodium, strontium, sulfate, sulfide, telluride, thiocyanate, thiols, water hardness and zinc It may not be possible to purchase all the ion selective electrodes and it is also not advisable because many of these electrodes have a specific life period, but some of the frequently used electrodes may be purchased

Polarography

Polarography is very useful technique in which potential is varied and the corresponding current produced due to the reduction or oxidation of the analyte is measured and the measured current is directly proportional to the analyte concentration Now most of the elements and compounds both inorganic and organic have specific redox potentials which can be exploited for their analysis It can be used for the analysis of heavy and toxic metals like, nickel, cobalt, cadmium, lead, chromium, copper, zinc, tin, arsenic, selenium, molybdenum and aluminium It can also be used for the analysis of petroleum, nitrate, nicotine, fructose, org. compounds, nitrilotriacetic acid (NTA), EDTA, Vit C, S, SO_3, S_2O_3, cyanide, inorganic anions, quinine, ammonia, nitrite, styrene and many others.

Stripping Voltammetry

Coulometry

In this technique the quantity of electricity required for an analyte to undergo a chemical reaction is measured which is proportional to the analyte concentration. This is a simple method for the measurement of a large number of constituents e.g; chloride, bromide In this technique the anlyte to be measured is first preconcentrated electrolytically on the electrode and then current is measured during the stripping process. In this way analyte can be preconcentrated by more than ten thousands times in the electrode as compared to its concentration in the solution. This technique makes it possible to measure trace metals in water upto the level of 1ng/l A large number of trace metals can be measured by this technique which include cadmium, lead, copper, silver, mercury, selenium, iron, manganese, barium, bismuth, cobalt, cesium, nickel, cobalt, uranium, tin, zinc and many others, iodide, acids, nitrate, ammonia, uranium etc.

Conductometry

Conductivity is a measure of total dissolved solids in water. It is also used in ion chromatography as a detector system

Determination of heavy and toxic metals (Cd, Pb, Cu and Zn) in drinking water.

A large number of water samples were analysed from Rawalpindi and Islamabad area for these metals Samples were collected from Simly dam, Rawal dam, and also many samples were collected from specified areas of Rawalpindi and Islamabad. Well water and Tube well water samples were also analysed. Values of Cd, Pb, Cu and Zn in surface water samples were in the ranges of 0 01 to 0.24 µg/l, 2 4 to 14.2 µg/l, 1.2 to 4 3µg/l and from 4 39 to 17.96 µg/l respectively. The values of Cd, Pb, Cu and Zn in ground water samples were in the ranges of 0 08 to 0.38, 0.33 to 5.30, 0.56 to 4.93 and 5 4 to 200µg/l respectively. All the values are well within limits.

Analysis of mineral water samples

Six types of mineral water samples were collected from the market and analysed for different constituents. Values are given in Table-4. pH of all the samples is about 8. Total hardness and chloride contents of M_1 sample are high. Levels of calcium, magnesium, carbonates, sodium, potassium are within the permissible limits.

Removal of Pollutants from Water

Electrochemical methods are very good for the removal of different pollutants from water[8] Eco-Cells are available for the removal of toxic metals from industrial waste[9]. Electrodialysis has been used for the removal of salts from water. Electrochemical reactors are available for the removal of different pollutants from water[10]. Electrochemical reactors consist of charcoal filters kept at a certain electrochemical potential. Many organic toxic pollutants are reduced or oxidized at those potentials into non toxic compounds, whereas inorganic ions are removed selectively by electrochemical deposition These electrochemical reactors can be regenerated by reversing their electrochemical potential.

Table 4: *Analysis of Mineral Water Samples*

Constituents	M_1	M_2	M_3	M_4	M_5	M_6
pH	8 0	8 1	7 9	5 5	8 3	8 3
Conductivity	1959	760	487	823	403	524
T Hardness	624	232	226	386	140	180
Ca-Hardness	300	116	112	300	12	24
Mg Hardness	324	116	114	88	128	166
Chloride	570	102	17	47	60	85
Carbonates	Nil	16	40	Nil	Nil	Nil
Bicarbonates	252	264	280	400	140	102
OH^- Alkalinity	252	280	240	400	140	102
Sodium	200	75	95	24	24	25
Potassium	1 0	4 0	5 0	1 0	2 0	-
Sulfate	120	40	40	25	2 0	-

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NITRATE POLLUTION IN DRINKING WATER AND ITS MEASUREMENT

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ABSTRACT A rapid and accurate method based on ultraviolet multiwavelength absorptiometry for the direct determination of nitrate in natural and potable waters is used After acquisition of data for sample at 1 nm interval between 205-250 nm, the proposed computational procedure gives in a few seconds the concentration of nitrate The principle is to use a polynomial correction function to cancel numerically the interferences from suspended and organic matters and to resolve the system formed by the sum of the absorbance of nitrate and the interference function Matrix calculation is made with MATLAB® software, the least squares method minimizes the error between the measured absorbance and the model The characteristics of the UVMA methods and the residual interferences have been evaluated and comparison with the reference method has shown that nitrate measurement by UVMA is a valuable tool for the fast and /or continuous monitoring

Introduction

The nitrate pollution in water has increased since 1960[1] and excessive use of nitrogenous fertilizers have been blamed for it But other factors such as changes in land use and recycling of sewage effluents in low land water although not large in Pakistan must also be considered

It is well known that nitrate combines with human blood and forms methaemoglobinemia[2] due to which oxygen carrying capacity of blood decreases and is mostly found in the bottle fed-children Excess nitrogen causes eutrophication in surface waters and alongewith phosphates causes algae growth Also, ingested nitrate is reduced in adult stomach and after reaction with secondary amines forms N- nitroso compounds most of which are carcinogenic

Many methods are available in the literature for the determination of nitrate Ion selective electrode method, although rapid, but has the limitations such as poor sensitivity and numerous interferences UV technique appears to be ideal as many people are using it due to simplicity and speed inspite of interferences which have to be corrected by various procedures Interferences are not eliminated completely by two wavelength method[2] because regression parameters vary from sample to sample and a calibration curve for each type of water is needed

In the present study UVMA method proposed by O Thomas[3] has been utilized after interfacing of UV-1201 Spectrophotometer (Shimadzu, Japan) with IBM PC This method has the advantage that it neither needs pretreatment nor pre-separation of components

UVMA Principle

The main problem with the previous methods is the need to take into account the numerous interferences in the region of interest Turbidity due to colloidal and suspended matter and organic materials are the main factors of featureless ultraviolet spectra of water. If we assume that there is an infinite number of organic components we would need to identify and characterise all of them to estimate their effect. Since this is not possible, an estimation of these interferences can be proposed, if we recognise that all ultraviolet spectra of natural water or treated wastewater with low nitrate concentrations have the same form· a featureless and decreasing shape The choice of an estimation function is of great importance and the best adjustment has been obtained with a polynomial function

So for each wavelength λi, the measured absorbance $A(\lambda i)$ is the sum of two absorbances.

$$A(\lambda i) = Am(\lambda i) + \sum_{j=1}^{p} \varepsilon j(\lambda i) \times Cj \tag{1}$$

Where $A(\lambda i)$ is the measured absorbance value at the wavelength $\lambda i, Am(\lambda i)$ the theoretical absorbance value given by the sum of all the interfering species except the p components to be measured, and $\varepsilon_j(\lambda_i)$ and C_i are respectively the absorptivity and the concentration of the jth component at wavelength λi (optical pathlength is assumed to be 1 cm)

Mathematically, this method is based on the fact that any function Am can be approached by a polynomial of q degrees From a numerical point of view, the advantage of polynomial modelling of the function Am, is to replace a function which is the sum of an infinite number of unknown functions by a defined number of known functions $(1, \lambda, \lambda^2, \lambda^3, \ldots, \lambda^q)$ with a defined number of unknown parameters (a_0, a_1,. ,a_q) these parameters are in fact the polynomial coefficients which will be calculated with the unknown concentrations (C_1, C_2, ., C_q) of the p components to be measured

The program computes simultaneously the polynomial coefficients and the unknown concentrations of the components to be measured, by solving the system

$$'M\,M\begin{pmatrix} C_1 \\ \cdot \\ C_p \\ a_0 \\ \cdot \\ a_q \end{pmatrix} = 'M\begin{pmatrix} A(\lambda 1) \\ \\ \\ \\ \cdot \\ A(\lambda n) \end{pmatrix} \qquad (2)$$

Where M is the matrix

$$M = \begin{pmatrix} \varepsilon 1(\lambda 1) & ..\varepsilon p(\lambda 1) & 1 & \lambda 1 & .\lambda 1^{q} \\ \cdot & \cdot & & & \\ \varepsilon 1(\lambda n) & ..\varepsilon p(\lambda n) & 1 & \lambda n & \lambda n^{q} \end{pmatrix} \quad . \ (3)$$

The system[3] gives as its solution the values of the coefficients (a_0, a_1, ..,a_q) and the concentrations (C_1, C_2 , C_q) that minimise the difference between measured and computed values of the absorbance, for each wavelength λi in the least squares sense.

This method is very suitable for our purpose because polynomial restitution, with a degree 3, leads to a close approximation of the background function.

Procedure

A UV-1201 (Shimadzu, Japan) spectrophotometer has been used for this work Before the first measurement, the determination of the absorptivities was carried out on a 4 0 mg/l nitrate standard solution (prepared with KNO_3 and distilled water) The absorbances of the standard solution were measured at 1 nanometer intervals between 205 and 250 nm and transferred to the computer program written in MATLAB ® for IBM personal computer (PC) (which calculates and stores absorptivities as data) The sample was then directly placed into the 10 mm quartz cell without adding any reagent or pre-treatment, and the absorbance values were transferred and used as data in the program

The computation is as described before (with a polynomial of third degree for interference elimination) with addition of the nitrate concentration. The required time for the complete method, from setting the cell to the result is about 30s Another important feature of UVMA is that it needs no calibration curve.

Discussions

Figure 1 curve A shows the typical spectrum of sample containing nitrate and suspended matter whereas curve B is the spectrum obtained by calculating Am from the coefficient calculated by the said Matlab® program The difference between the two being the actual spectrum of nitrate present in water. Also, it is clear from the spectrum that UV absorption due to suspended and organic matter is significant at the wavelength 205-230 nm where nitrate measurements are usually made.

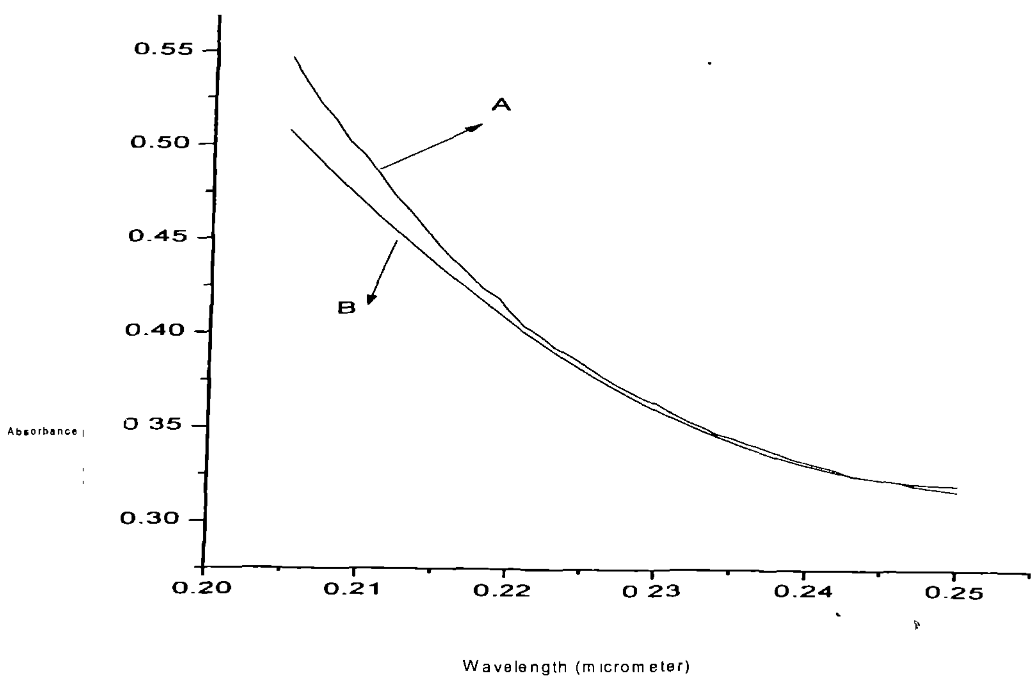

Figure 1 (A) A typical UV spectrum of water sample
(B) Computed spectrum of the background function Am as
$Am = a_0 + a_1\lambda_i + a_2\lambda_i^{2} + a_3\lambda_i^{3}$ (a_0 = 4.372, a_1 = - 24 273, a_2 = - 0 005, a_3 = 129 035)

Table 1. *Comparison of results by UVMA and Colorimetric Reduction Method*

S. No.	Water Sample	UVMA (mg/L)	Colorimetric (mg/L)
1	Tube well near Nilore, Islamabad	0.19 ± 0.01	0.2
2	Malal bridge site i) with suspended matter ii) After centrifugation	 1.30± 0.06 1.41± 0.05	 1.2 1.3
3	Standard addition of NO_3^- to sample 2 (ii)	2.10 ± 0.10 2.71 ± 0.16	2.1 2.6
4	Waste Water (PIEAS)	*Large error in polynomial coeff	2.4

- UV spectrum was not smooth so could not be fitted properly

The validation of the UVMA method has been done with samples of drinking water and wastewater including surface and underground waters of various origin and compared with the reference method (Colorimetric reduction method). All the concentrations found are within the World Health Organisation (WHO) limit of 50 mg/L as NO_3^- [4]. The results obtained by UVMA method are in good agreement with those obtained by other reference method. But in case of wastewater the results obtained by UVMA are not satisfactory and further investigation is being done.

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ANALYSIS OF POTABLE WATER IN DERA GHAZI KHAN

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ABSTRACT Water used for daily life in D G Khan has been analyzed for estimation of total hardness, chlorides, sulfates, silica and other related parameters Samples of ground water (tube wells), canal water and water supplied by the local administration were collected for these studies The results show very high levels of hardness and sulfate concentrations in underground water sources Total dissolved solids in canal water are appreciably lower than those found in sub-surface water samples The results are discussed with reference to the quality of water for drinking purpose

Introduction

Water for domestic purposes should be obtained from a source representing a clean and uncontaminated supply and as far as possible it should be free of animal waste, vegetable matter and industrial effluents. Normally good quality water should be clear, colourless, odorless, well aerated, cool, soft and free from toxic pollutants, sediments and suspended matter[1,2] Although many parameters affect the quality of water, yet the pH, total hardness, temperature, turbidity, coliform and phenols in certain cases my form the basis for the selection of a water body for human consumption[3]

This paper describes some of the results of analysis carried out on drinking water samples taken from within the main city of D G Khan Various samples for this purpose were collected from underground sources, D G Khan canal and water supplied by the local administration

Experimental

Chlorides, alkalinity and total hardness were determined employing titrimetry silica and phosphates were estimated by standard spectrophotometric procedures. All the analytical methods used conformed to the ASTM specified and recommended procedures [4]

Results and Discussion

The results of analysis conducted on different water samples used for domestic purposes in D G Khan are presented in Table-1 All the water samples are slightly alkaline in nature Solubility of aluminum is <1 ppm between pH 4-9, whereas most of the iron is precipitated out around pH-8[5-6] This suggested that these water samples would be relatively free of aluminum and iron impurities as visible from the analysis data Very high levels of total dissolved solids (TDS) particularly in sub surface water (1616 and 1577 ppm) could be as a result of the prolonged stagnation of water coming from the hilly terrains of Suleman range where the sedimentary rocks are known to bear water having high concentrations of salts In addition to this, the high temperature and low annual precipitation (<10 inches/year) may also contribute to the high concentration of TDS The sandy limestone clay rich in carbonates and bicarbonates is the main cause of hardness in these samples[7] However, the running water collected from the canal has low level of total hardness

Sulfate concentrations of 759 mg/l and 688 mg/l in tube well water samples are higher than the permitted concentration of 200 mg /l [8] This could be due to the fact that the most abundant mineral in the D G Khan division is Gypsum Establishment of a cement factory near D G. Khan city may further strengthens the argument about the high concentrations of sulfates. However, water supplied by the local administration has concentrations of sulfates within the permissible range[8], which suggests that water is chemically softened before supplying to the house holds As a result of the calcareous nature of the soil, silica content in these water samples in low[7]. Low levels of chlorides point towards the presence of ca and Mg salts as TDS with very small contribution from NaCl As this type of soil is mature with practically no phosphate bearing minerals, very low concentrations of phosphates were detected in these water samples

Table 1 *Results of Water Analysis*

Parameter	Twa	Twb	Mca	Mcb	Cwa	Cwb
pH	7 55	7 5	7 6	7 6	8 0	8 05
TDS - mg/l	1616	1577	692	676	372	370
T Hard mg/l	679	648	308	319	122	143
Sp Cond μs/cm	1740	1590	810	894	240	363
Alkalinity mg/l	188	181	181	178	100	106
Chlorides mg/l	54	54	56	54	18	25
Sulfates mg/l	759	688	122	134	34	28
Silica ppm	16 0	16 4	15 4	13 9	5 7	8 1
Phosphates ppm	< 1 0	< 1 0	< 1 0	< 1 0	< 1 0	< 1 0
Susp Part Mg/l	Nil	Nil	Nil	Nil	Nil	Nil
Oil & Grease	Nil	Nil	Nil	Nil	Nil	Nil

Tw = Water from tube well, Mc = Water supplied by the local administration, Cw = Water from D G Khan canal

No suspended particles were detected in the water samples except in those taken format he canal. This is the result of the erosion of sandy soil[9] coming in contact with water of D. g. Khan canal originating from Tunsa barrage There was no bad odor, oil and grease in these water samples.

The results of analyses suggest that potable water in D G Khan city is very hard having high levels of sulfates and TDS Maximum permissible levels approved by the Environmental Protection Agency of Pakistan are 200,500 and 200 mg/l for total hardness. TDS and sulfates respectively[10] This has resulted in stomach and kidney stone problems in the city The cheapest remedy for softening this hard water is boiling before use. This has two fold advantage of decreasing the hardness as well as removing the harmful bacteria

Low concentration of chlorides in the potable water supplied by the local administration indicated that the public health department is using a method other than chlorination for the sterilization of water It may most probably be using the Lime-soda process that softens water besides sterilization[1 8] This process precipitates out carbonates, bicarbonates and sulfates of calcium and magnesium

These results are being presented with a view to outline the drinking water quality data obtained in this limited study for information of audience of the one day workshop on quality of drinking water.

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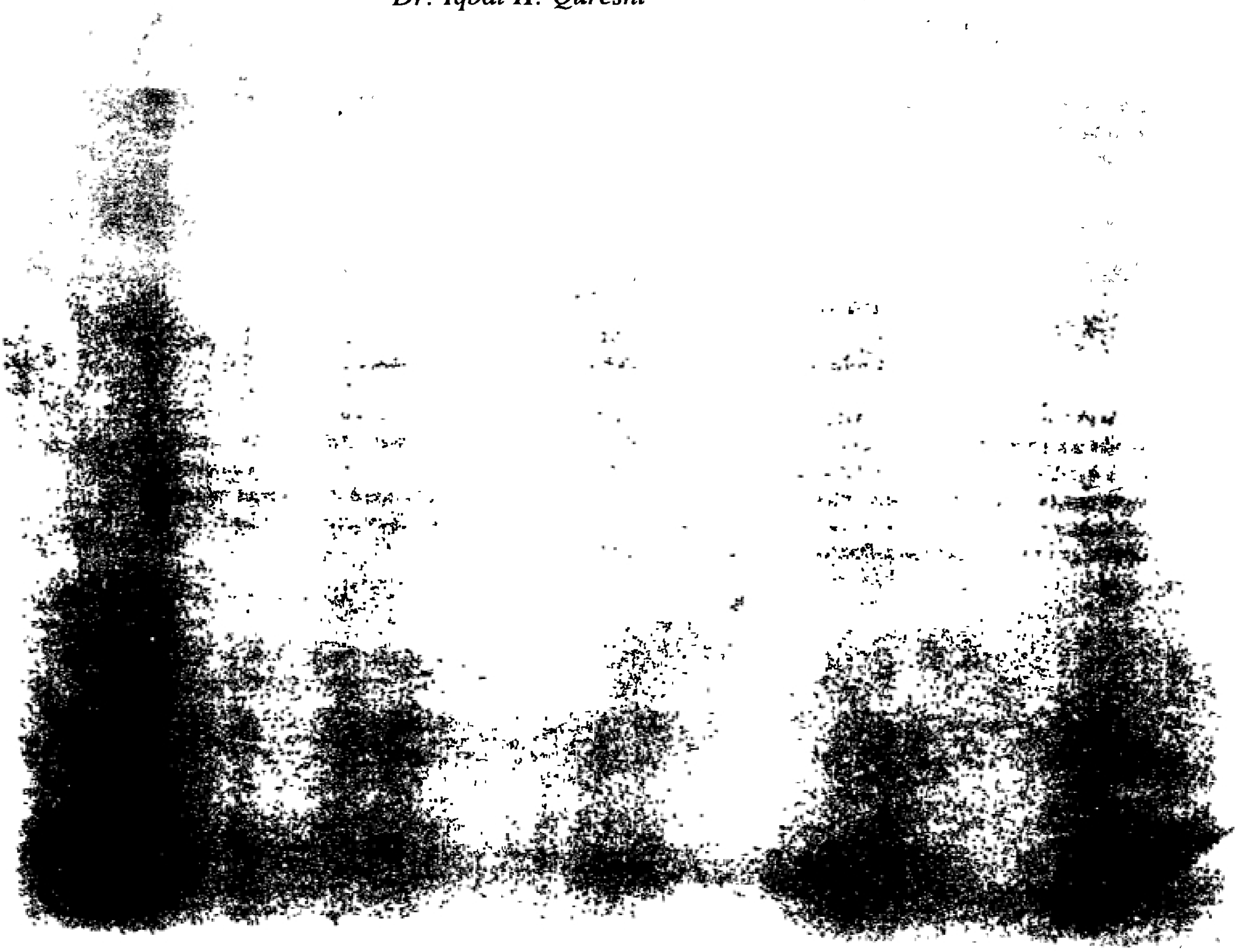
ABSTRACTS OF SELECTED PAPERS

Clean and Safe Drinking Water for All
Muhammad Akram Chughtai

Quality Control of Drinking Water
Mian Muhammad Aslam

Parameters of Water Quality
Dr. Iqbal H. Qureshi



CLEAN AND SAFE DRINKING WATER FOR ALL

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The main theme of this presentation is to create an awareness for clean and safe drinking water amongst the people as contaminated water may lead to many health problems This paper covers the introduction to water purification systems, its different stages, materials used and their suitability including the process of purification itself Amongst the materials, activated carbon is considered to be very important component. It's properties with reference to it's use in water purification systems such as bulk density, ash contents, CTC valve, mesh size and hardness have been discussed Brief discussion on various disinfectants used in the purification systems to distroy the micro-organisms responsible for quality deterioration has also been mentioned at the end

QUALITY CONTROL OF DRINKING WATER

Mian Muhammad Aslam
Water Quality Control Unit, Capital Development Authority (CDA), Islamabad

Significance of water testing has been highlighted with reference to Islamic Ideology and WHO guidelines. For the operation and maintenance control of a water-supply system critical parameter testing strategy has been preferred over less frequent lengthy testings A brief account regarding the water borne diseases emanating from the pathogens as well as from the inorganics has been. It has been recommended that sanitary inspection should take preference over analysis for the assessment of risk to human health due to contamination It has been elaborated that the CDA uses the conventional methods of coagulation, flocculation, sedimentation, filtration and disinfection for the preparation of potable water For the oxidation and disinfection purposes liquefied chlorine is used The major source of surface water for Islamabad is Simly Dam Ground water is obtained from the tubewells installed in the National Park area, and the spring water from the Saidpur, Noorpur and Shahdara-hill springs Finally a note explaining the reasons of polluted water complaints has been added

PARAMETERS OF WATER QUALITY

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Water is the most essential component of all living things and it supports the life process Without water it would not have been possible to sustain life on this planet The total quantity of water on earth is estimated to be 1 4 trillion cubic meter. Of this less than 1% water present in rivers and ground resources is available to meet our requirements These resources are being contaminated with toxic substances due to ever increasing environmental pollution To reduce this contamination many countries have established standards for the discharge of municipal and industrial waste into water streams

RECOMMENDATIONS

RECOMMENDATIONS

1 The workshop feels that there is a general lack of awareness in the masses regarding the diseases and ailments associated with poor quality of drinking water. It is therefore, recommended that a national level campaign should be launched through mass media to create general awareness in the public Different NGOs and the Government agencies should work together to create general awareness through trainings, workshops and outreach programmes.

2 This workshop notice that though various health problems have emanated due to use of poor quality water yet country has not adopted drinking water quality standards. It is stressed that these standards should be developed immediately and enforced in accordance with the Pakistan Environmental Protection Act passed by the Parliament in December, 1997.

3. Pakistan has witnessed a modest growth in the mineral and natural water supply industry in the country over last few years. However, most of the individual industries are not processing and bottling water according to guidelines and standards set by WHO or national standards. This workshop, therefore, stresses the necessity to standardize all procedures and the techniques to process and bottle mineral/natural water before marketing. The source of such water should also be properly assessed and certified by an authorized agency.

4 This workshop recommends that a federal water quality monitoring and licensing agency should be established with a mandate to monitor the quality of drinking water and to ensure implementation of water quality standards in the public as well as private sector. This agency may be mandated:

(a) to set up guideline values for water quality standards in Pakistan which may be updated time to time on the basis of continuous research and monitoring;

(b) to set up standard procedures and techniques for operation, maintenance and certification for quality testing laboratories in respect of water treatment, potable water marketing, and quality assessment; and

(c) to establish a panel of laboratories which may act as nucleus for standardization of procedures required for quality control and quality assurance of drinking water.

6 It is generally observed that Municipal Water Supply in Pakistan, even in big cities, does not meet the WHO or any other laid standards. Due to poor maintenance practices a pipe lines at places get damaged and result in getting mixed with the nearby leaking sewerage water. It is recommended that steps should be undertaken to ensure that Municipal authorities undertake periodic random checking of water quality and take appropriate remedial measures to ensure quality of the drinking water that reaches the end users.

7. The contamination of water drawn from wells, hand and other pumps etc. is very common due to presence of nearby septic tanks and pit latrines in the rural areas and small towns. The problem needs to be studies in detail to arrive at appropriate designs of the whole system in order to get contamination free drinking water.

8. This workshop recommends that simple procedures and techniques such as simple chlorination should be used for disinfection of drinking water stored in underground and overhead tanks. People to be educated on such techniques through mass contact.

9 Standards water quality analysis laboratories should be established in all provincial and Divisional Headquarters. There is an urgent need of a central well-equipped laboratory, which will act as the certification laboratory for all other laboratories available in the country.

Sd/-	Sd/-
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