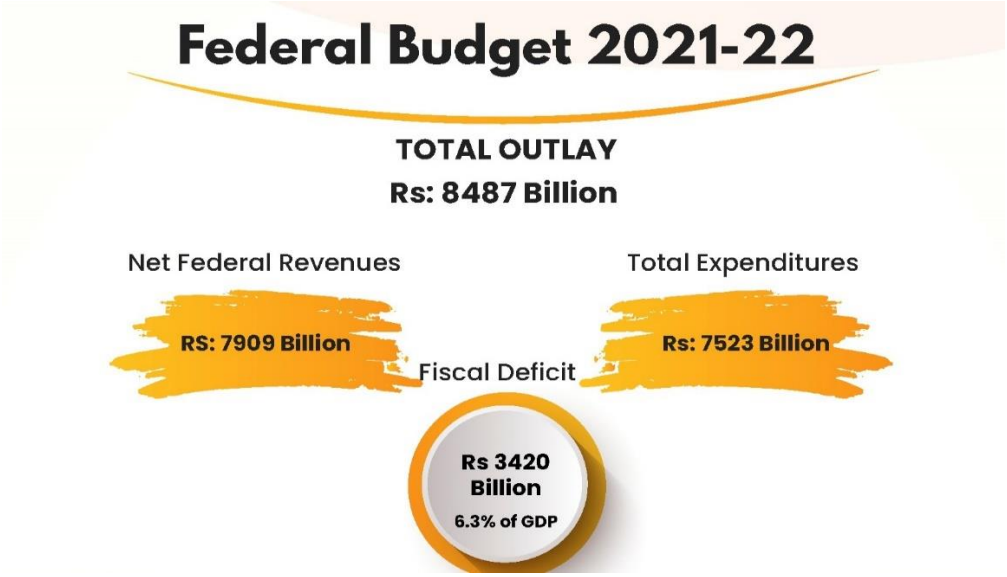
January-June 2021

SDPI
Sustainable Development Policy Institute

Research and News Bulletin

Vol. 28, No. 1 & 2



"In the current circumstances, the government has tried to offer a balanced budget. For example, the focus on reducing cost of doing business, revival of agriculture, supporting exports, and improving purchasing power of the poorest are all measures that could help the country consolidate on past gains and move to a higher growth trajectory. Simplifying withholding Tax regime and reducing the discretionary powers of FBR are a positive step. Allocation for low-cost housing as well as collateral free loans to SMEs are also welcome steps. Though 10% increase in pays and pension, and minimum wages is not sufficient, but it is encouraging in the present circumstances. Similarly, increase in Ehsaas Fund for afforestation (especially for 10 billion tree plantation) will provide a fresh air. We conclude with, as described by the finance minister himself, 'there is something for all in this budget'."

Contents

Editor: Saleem Khilji

A Policy Analysis of Budget 2021-22

Good News, Bad News and Four Ds

Budget 2021-22 has something positive for almost all sections of society. However, things that pinch an ordinary citizen are no more under the budget purview.

Dr Abid Qaiyum Suleri

While listening to the budget speech of Finance Minister Shaukat Tareen, my initial reaction was that the minister has tried to reduce the cost of doing business. Abolition of 40 per cent withholding taxes, withdrawal of customs and regulatory duties on many items, curtailment of FBR officials' discretionary powers, and introduction of third-party audit in case of any dispute between FBR and the taxpayer would result in a reduced cost of doing business, improve ease of doing business, and – if implemented as perceived – help improve the trust deficit between taxpayers and tax collectors. Reduced cost and improved ease of doing business will help revive the economy that should, in turn, result in additional revenue collection, and a rationale for the historic high revenue target in the budget.

Good News

In the Federal Budget 2021-22, the good news is the abolition of a dozen withholding taxes. It has reduced General Sale Tax (GST), regulatory duty, import duty, additional import duty, Federal Excise Duty (FED), and Value-Added Tax (VAT) for many industries and sectors. Some of the beneficiaries (subject to conditions) of the above-mentioned measures include manufacturers/importers of cars up to 850cc and those of electric vehicles, manufacturers of medical and surgical apparatus, local fruit juice manufacturers, paper industry, wood industry, yarn industry, shoe industry, machine-made carpet industry, Ready to Use Supplementary Foods (RUSF) and Ready-to-Use Therapeutic Food (RUTF) producers/importers. The list goes on to include telecommunication services, warehouse services, travel and tour services (domestic air travel), oilfield services, etc. Duty and tax benefits for these industries will reduce the prices of some of the goods and services.

Another good news is that at least an attempt has been made to enhance the purchasing power of people (based on their eligibility for different initiatives). To this end, salaries and pensions of government officials has also increased by 10 per cent. After three years, it has raised the minimum wage. There is a large allocation for the flagship Ehsaas Programme (through which cash is disbursed to targeted beneficiaries). There are plans to provide loans to the agricultural sector, Small and Medium Enterprises (SMEs) as well as urban household.

The third good news is that the health sector is on the policymakers' radar. Provision of funds for the procurement of COVID-19 vaccines, and allocations for measures to contain COVID-19 are steps in the right direction.

Allocation of a substantial amount for subsidies is also a good news, but a large chunk of this amount will be spent on making payments to Independent Power Producers (IPPs).

The last good news is a promise by Finance Minister to end FBR's discretionary powers, the

introduction of third-party audit and confidence-building measures to reduce the trust deficit between tax collectors and taxpayers. The corporate sector will benefit from reduced taxes. However, the benefit will not directly go to the masses.

Bad News

Now, let us turn to some of the potential bad news. The proposal to give FBR officials the power to make arrests for tax evasion is not consistent with the stated objectives of building trust between taxpayers and FBR. The government will do well to be more consistent in its messaging to the people.

The government plans to fetch an additional Rs 85 billion (12 per cent higher) through customs duties, an additional Rs 579 billion (30 per cent increase) through sales tax, and an additional Rs 81 billion (29 per cent increase) through federal excise duty. It also plans to collect an additional Rs 392 billion (22 per cent more than last year) through taxes on income. One may argue that tax on income will pinch those who have income above a certain threshold and will not affect the masses. However, Rs 745 billion is to be collected through indirect taxes. The indirect taxes are regressive and hurt the low-income earners more.

These taxes will raise the price of sugar (Rs 7 per kg GST added in the retail prices), processed and packed dairy products (subject to GST now), online shopping, LNG, silver, gold jewelry, tyres, and many other items.

The elephant in the room is energy prices, which are linked to the crude oil prices in the international market. These are normally determined by the Oil and Gas Regulatory Authority (for oil and gas) and the National Electric Power Regulatory Authority (for electricity) and not discussed in the federal budget. The sale price of petrol to the consumer includes the costs of refineries and oil marketing companies, dealers' margin, inland freight equalization cost, general sales tax (which is shared with the provinces), and petroleum levy (which is the federal government revenue). The upper cap for petroleum levy is Rs 30 per litre in the case of petrol. The government compromises on income to be collected through petroleum levy to safeguard the domestic consumers from an abrupt increase in petroleum prices globally.

Currently, the prices of crude oil are around $74 per barrel (almost double the low a few months ago). The Oil and Gas Regulatory Authority (OGRA) has been recommending an increase in domestic prices of petroleum products. The prime minister rejected the OGRA recommendations for several weeks until the prices were raised earlier this week.

For the next year, the government has budgeted a Rs 600 billion collection through the petroleum levy. Currently, the levy charged is Rs 4-6 per litre. To meet the ambitious target of Rs 600 billion, it will have to be increased significantly. Meanwhile, crude oil prices are expected to touch $90 per barrel by the end of 2021. Fuel inflation will, in turn, trigger cost-push inflation.

Likewise, the electricity tariffs will likely be revised upwards to contain the so-called energy circular debt. The tariff revision will include a 'rationalization' of subsides. The subsidies will likely be diverted mostly to lifeline consumers.

The budget has many pro-growth measures. The downside is that while these may increase purchasing power, inflation will be hard to contain. The lower-middle-income and middle-income groups will

bear the brunt of inflation as well as the impact of diversion of subsidies. The poor apparently have nothing left to lose; the rich are largely immune to the price-hike shock.

Four Ds

The art of preparing budget in Pakistan means balancing the needs with resources. These needs may be classified into four Ds, i.e. debt servicing, defence, day-to-day administration, and development. Resources are generated from two streams: federal revenues (tax collection and non-tax income) and borrowing (from domestic banks as well as external sources). Since the needs always outrun the resources, the makers of Pakistan's budgets continuously struggle to match them.

What makes this complicated task even more complex is that the strings attached to borrowing from the International Monetary Fund (IMF) are always directly linked to such budgetary indicators as tax collection, inflation, primary deficit, interest rate and currency value. When Pakistan is getting financial assistance from the IMF, as it is doing now, the making of the budget starts with the setting of a target for primary fiscal deficit – the gap between revenue and expenditure after debt servicing. The revenue gets inflated, and the expenditure is deflated in such a way that the imbalance between them does not exceed an IMF-mandated deficit target.

A 'V'-shaped recovery of a COVID-struck economy resulting in double than expected growth (3.94 per cent) for the outgoing fiscal year helped Finance Minister Shaukat Tarin make some bold moves by saying no to the IMF's standard recipe of resource mobilization. Refusing to increase the tax burden on existing taxpayers and resisting the demand for electricity tariff increase, he is eying on expanding the tax net through the use of data and technology.

Something for Everyone

The good thing is that the budget has something positive for almost all sectors of life. The industry and corporate sectors seem satisfied on the different measures that would improve their profitability and productivity. Agriculture is a provincial subject, and provincial governments are likely to allocate money for agriculture. However, the federal government too has allocated money for some vital interventions in the agriculture sector. The duties on silos and warehouses are reduced to enable the farmers to store their produce and avoid exploitation by middlemen. Provision of collateral-free loans for Small and Medium Enterprises (SMEs) will help them continue to provide jobs in the informal sector.

Reduction of duties and taxes on small vehicles (on average a small car would be Rs 200,000 cheaper) will help some to graduate from motorbikes to cars. It will also increase the production of small cars, creating some jobs as well as additional revenue for the FBR. Likewise, record allocation for different initiatives of the Ehsaas Programme, for afforestation, water security, the COVID-19 vaccine, power infrastructure, reducing regional disparities, climate change, and a special grant for Sindh are all steps in the right direction.

To improve the purchasing power of the people, the minimum wage has been increased to Rs20,000 per month. Likewise, a 10 percent increase has been made in government pays and pension. Admittedly, these increases are not sufficient to cope with inflation. However, let me take you back to the four 'Ds' and limited resources.

Revenues and Expenditures

Net federal revenue after provincial share from the divisible pool for the next year is budgeted at Rs4497 billion. On the expense side, the three mandatory and non-discretionary expenses – debt service/repayment (Rs3060 billion); defence (Rs1370 billion); and (running of) day to administration, pay and pension (Rs1119 billion) are budgeted at Rs5549 billion. There will be a shortfall of Rs1052 billion to meet these mandatory expenditures.

Development-related expenditures, which include PSDP (Rs900 billion), grants and direct transfers (Rs1850 billion), subsidies (Rs682 billion), and COVID-19 related expenses (Rs125 billion) are non-mandatory and discretionary expenditures (that's why they are often curtailed) and are budgeted at Rs2875 billion. The total shortfall for the above-mentioned four 'Ds' is Rs3927 billion.

The government is expecting some proceeds from privatization and some provincial surplus but would have to borrow at least Rs3200-3500 billion if it gets some additional revenue from the above-mentioned heads. This calculation is valid if the government sticks to the budgeted fiscal deficit. Any unforeseen expense or slippage in revenue (increased fiscal deficit) – and the need for borrowing would increase.

Let us talk of some bad news as well. The bad news is that the things that pinch an ordinary citizen are no more under the purview of the federal budget. I am referring to energy prices; electricity and fuel – both oil and gas – whose prices are determined by NEPRA and OGRA and are linked with the international market.

The government has resisted the IMF's demand to increase the component of petroleum levy in the budget, yet the way petroleum prices are increasing in the international market (today's price of crude is $71 per barrel), it will soon be impossible for the government to keep subsidizing the oil process. Commodity prices in the international market are also increasing. This will influence domestic prices of edible oil, pulses, and other imported items. If these trends continue, the government will have to borrow more – or pass the impact on to the consumers.

(The earlier versions of this analysis were published in *The News*.)

Budget 2021-22: Some Limitations

The government's key test would be to negotiate some fiscal space with the IMF to ultimately use resources for sustaining above 4.5% GDP growth in the next fiscal.

Dr Vaqar Ahmed

After the announcement of the federal budget in Pakistan, people are often disappointed to learn that the budget exercise may do well in keeping government operations running but will do little to create a dent in structural ills facing the economy. For a vast majority of population, budget also doesn't result in higher levels of salaries and payoffs; minimum wages announced are rarely observed; given the vested interests involved in negotiations (within coalition government) there is little potential of reduction in medium term budget deficits due to which budget's impact on inflation is also marginal. Budget is also not the answer to the missing structural reforms in public finance management, energy, and state-owned enterprises.

It is due to these reasons that fiscal policy should be viewed not only as a one off-budget presentation but also as a strategic opportunity to put the country on the path of economic recovery, growth, productivity, and job creation.

I do see a couple of good beginnings. For example, GDP growth of 3.9 per cent amid COVID-19 is good news for all stakeholders. One still has to see how sustainable this growth process will be as in the past whenever we had growth spurts, Pakistan landed into either a current account predicament or higher fiscal deficits. One is also not sure about the future waves of COVID-19 and how these will bring back micro lockdowns, in turn, negatively affecting production in several sectors.

Second, I also see hope in the way things have taken shape on the tax front. The Federal Board of Revenue (FBR) was able to collect PKR 4.2 trillion during the period between July 2020 to May 2021. This exceeds the target of PKR 3.9 trillion and represents 17% growth during the same period last year. More needs to be done now to reduce compliance costs faced by genuine taxpayers and narrow the trust deficit with corporate taxpayers, and wholesale and retail sectors. Ultimately, we need to understand that a modern tax system is one of the pre-requisites to sustainably finance human development and infrastructure across the country.

Third, I believe that after a very long-time consideration of environment, food security, and climate change have factored in our economic discourse. It is only now that we see our Finance Division and Planning Commission really taking ownership of climate change threat to the country and protecting budget allocations towards this. The positive spillovers of going this path are enormous. These developments have also given rise to innovative financing of clean energy, including launch of green bonds. We are also noticing how tree plantation drives and reversing land degradation in several provinces and particularly Khyber Pakhtunkhwa over the past few years has led to revival of several economic activities, including tourism, and benefited local communities.

Among other bright spots in the economic performance, the government can also take credit of growth in digital sector businesses, e-commerce, and integrating Pakistani sellers with international platforms like Amazon. The policies for construction sector and most notably Naya Pakistan Housing Scheme is also starting to bear fruits with allied industries showing an uptick in turnover. This has also been

fueled by facilitation provided to diaspora now sending record high inflows.

Going forward, the government's key test would be to negotiate some fiscal space with the International Monetary Fund, to ultimately use resources for sustaining above 4.5% GDP growth in the next fiscal year. This is going to be an uphill task. Any revenue target beyond PKR 5.5 trillion will require significant fiscal effort and a political resolve to go after those involved in tax evasion and avoidance. We also note that this year's target was met by higher reliance on indirect tax which are regressive in nature and hurt the poorest of the poor segments. Gradually, efforts need to be geared towards improving collection of progressive and direct taxes, which will shift the overall burden of taxation on the higher income groups.

The Finance Division will also need to exercise care with regard to the quality of economic growth. If growth gives rise to non-essential imports, then coupled with high expected oil and commodity prices this could result in balance of payment difficulties and jeopardize the nascent economic recovery. The role of provincial governments remains critical to Pakistan's fiscal consolidation.

Currently, seven different tax regimes in the country and at provincial level really means that a fragmented tax system is leading to higher costs for genuine taxpayers. Possibly the government is also losing out revenue because of this fragmentation. Lack of unified tax return system implies that taxes are being filed with federal, provincial, and local administrations, which leads to a higher cost of doing business. The long pending agenda of tax harmonization is awaiting attention of Council of Common Interests. Provinces have also struggled to tap into large income segments in agriculture, property, transport, and services sectors. In case it is politically not feasible for the provinces to tax their agriculture incomes or large landlords, the function may be given to FBR that could collect and transfer to provinces.

The drive towards documentation of the economy also needs care. Only smart documentation should be considered. Complex filing requirements could end up stifling the growth of startups and freelancers seen in several dynamic sectors including IT and digital products and services. These sectors are just starting to see growth and integration with global value chains.

Greater efficiency in public spending is need of the hour. Public Finance Management law was a step in the right direction. However, its understanding and implementation by line ministries remains slow. With interest payments and liabilities as high as 40% of overall federal spending, little is left for financing growth and productivity ambitions of the government. In near future, most social protection schemes, including Ehsaas, Kamyab Jawan, and even pensions expenditures, may have to be financed through raising more debt.

A recent report by the Economic Advisory Council suggests that rationalization in government expenditures is possible to the tune of PKR 300 billion annually if steps to reduce the size of the government are taken on priority. A moratorium may be introduced on development projects and no new political motivated or 'look good' projects should be added to Public Sector Development Programme until the time existing ones are completed or shut down to make room for new initiatives.

The pandemic is going to burden us with unprecedented levels of debt. We, therefore, need a more promising debt management strategy. A failure to put brakes on our borrowing needs will result in great injustice to our future generations whom we will leave burdened with more inflation, higher

needs for revenue collection, and even higher borrowing requirements. The public debt to GDP ratio of around 94% could easily climb up in the event of future depreciation in the value of Pakistani rupee. Last but not least diplomatic efforts to obtain debt relief, including waivers or reprofiling of future repayments, should be a priority of current and future governments.

(An earlier version of this text was published in *The News*.)

Will Artificial Intelligence and Human Intelligence Complement or Rival Each Other?

It is vital to innovate and create interface with computers and upload our minds to computers so that human and machine intelligence can multiply.

Brigadier Mohammad Yasin (Retired)

The day may not be too far away when we may be faced with the challenge of rivaling with Artificial Intelligence (AI). We Will be forced to determine if AI is help or hinderance? A very large number of organizations and companies around the world are focusing on AI because it promises to transform the world. Some forecasts say that in a few years' time, this technology could outpace human intelligence. Huge amounts are being spent and research being prioritized for possible benefits and risks of AI.

In fact, AI is not a new phenomenon as it has been in practice in one form or the other since the early fifties. There have been movies on robots performing various tasks like humans and we have been reading fictions depicting the future world. Now, the topic is real and popular. But what is AI? Simply stated, AI is the science and engineering of making computers and machines that would think as intelligently as humans. It is accomplished by studying how human brains think, learn, decide, and solve problems and developing algorithms to enable the machines to act as humans. Intelligent computers process large amount of data, information and pictures and they learn and improve without any special programming to do so.

A subfield of AI is machine learning, which is an application AI. It provides systems the ability to automatically learn and improve from experience without being explicitly programmed. It focuses on the development of computer programmes that can access data and use it to learn for themselves. Machine leaning again has a subfield called deep learning which processes huge amount of data to detect relationships and patterns that humans are often unable to detect. Deep means the number of layers.

AI and machine learning is enhancing the hardware and software within computers and smart phones thus making our lives easier with every update. "An average individual looks at his/her mobile phone for more than 2.5 hours and makes about 35,000 decisions in a single day", writes Ralf Lianasas, a tech writer and digital marketing expert. Mobile phone marketeers study behaviours of mobile phone users to find out customers' needs. Mobile phones are now designed to conduct AI tasks efficiently. Only three per cent phones had this capability in 2017, but in 2020 it was 35 per cent. According to various studies, an average smart phone has around one dozen sensors like accelerometers, GPS, microphone, camera, etc. For years, mobile phones have been gathering data on us through these sensors. The camera, AI and machine learning algorithms are capable of recognizing owner's face. May be one day, the 35,000 decisions or at least some of them that the owner makes will be taken over by the phones.

Now more and more mobile phones incorporate processors with deep learning based on neural networks. A neural network seeks to initiate functioning of the huma brain. This network can detect patterns and make decisions based on them. However, currently only 10 per cent smart phones have built in deep learning capacity, a feature that is forecast to reach 80 per cent by 2022.

Most people ask if AI can change the world with the innovations currently in vogue in many countries? In the years to come, the AI technology could even replace human intelligence. May be within 30 years, we will have flying cars, as huge amounts are being invested in this technology. In the field of autonomous or self-driving cars, according to Allied Market Research, the market is expected to hit $556.67 billion by 2026 which means a compound annual growth rate of 39.4 per cent. At the same

time, developing completely autonomous cars is not an easy undertaking because of security and safety issues. It may take more than 30 years before such cars come on roads.

According to various studies, China may become the leading player in AI within a few years. It has an ambitious goal of spending $150 billion by 2030 to promote this technology. It is speedily developing its human resource in AI and many young people are pursuing a career in this field. China is also working on erecting next-generation cities for autonomous cars besides aggressively working in 5G networks.

For many years now, robots have been used across a wide range of industry. With AI, work is being done effectively by employing robots in other areas like security of installations and defence fields. However, developing completely intelligent robots is a gigantic task, especially, when they must sense and negotiate the environment in which they are operating. With the speed of development, very soon robots may be working alongside humans to complement each other's strengths.

The US Air Force Research Lab is working on building robots that will be co-pilots in fighter jets and will take over if the pilot becomes incapacitated. Drones that are being developed would be capable of making decisions while flying over the target rather than being controlled remotely from the operation room. There have been significant advances in curing serious diseases by discovering appropriate drugs. The AI speeds up the process because it can identify complex patterns.

However, when all is said and done, there is a danger of significant technological unemployment because machines will be as intelligent as humans, and they will take over most professions. The expectation is that robots will outperform humans. There is, therefore, a need to explore how this transition from the present mode of working to AI based modes will take place. What would need to be done to replace present human skills with the ones that would work alongside machines.

It is vital to innovate and create interface with computers and upload our minds to computers so that human and machine intelligence can multiply.

In Pakistan, it is heartening to note that there is now greater awareness of the changes that AI would bring to us. Some of our universities are now offering training in AI which would produce the required human resource to work in this field. Pakistan has been able take advantage of AI in identifying the risks involved because of the prevailing pandemic. Efforts are also on to use AI in the agriculture sector, and monitoring weather. This would help forecast the impending disasters. However, Pakistan is far behind in tapping the benefits of AI. The government, under the Knowledge Economy Initiative, has allocated Rs 2500 million in the federal budget 2019-20, but it is still in the air. The amount was to be spent on research in the fields of Artificial Intelligence and Allied Technologies.

We must focus on the research and development of AI lest we miss the boat and lag many years behind in this fast-developing technology. Seeking Chinese help in this field would be a wise step.

Research on hazardous contaminants and polluted sites in Pakistan - A Review

Dr Mahmood A. Khwaja and Tahira Shamas

In Pakistan, wastes management has long been an issue of concern. Reviews and studies have been carried out on the chemical contamination of surface and sub-surface water bodies and soil in the close vicinity of different sites in the country. A national report gives an account of main sources of hazardous wastes in the country and various problems associated with these wastes, including non-availability of reliable data, and emphasized challenges and the needed efforts, in safeguarding and disposing of just a few tons, of outdated pesticides in Khyber Pakhtunkhwa (KP) province (Khan 2001). Studies on lead exposure and children has been reported by Khwaja (2003) and Shah et al. (2013). Blood lead levels were studied in schoolchildren, resulting from leaded petrol use and increasing road traffic (Khwaja 2003 & 2005) The reported level of Lead in air at 4 main cities indicated a very alarming increase and high levels of lead in the ambient air at the sites and time of monitoring. Recommendations of National Environmental Action Plan (NEAP) with special reference to clean air and provision of clean fuel have been briefly described and discussed (Khwaja, 2003).

Ahad et al. monitored and reported the organochlorine pesticides in soil and water samples from selected obsolete pesticide stores in Pakistan. The soils of obsolete pesticide stores in Pakistan contained high levels of organochlorine pesticides that threatened human health, water resources and the environment. The soil samples mainly contained DDT, followed by lindane and heptachlor (Ahad et al 2010). Plant transfer factors (PTF), daily intake of metals and health risk index (HRI) were calculated in the collected soil and vegetable samples which indicated that the leafy vegetables were highly enriched with heavy metals because of their capability to accumulate heavy metals from soil. Health risks of metals through ingestion of vegetables were of great concern in the study area (Khan et al. 2010) Prasad and Khwaja reviewed, “Hazardous Waste in the Asian Pacific Region,” and concluded that the production and disposal of hazardous waste remain a substantial problem in many countries of the Asia Pacific region, including Pakistan (Prasad and Khwaja 2011). SDPI study identified and investigated 39 polluted sites in 12 districts of 3 provinces of Pakistan as well as federal capital, Islamabad and of these 10 sites were listed as priority sites for remediation action/s at the earliest. (Khwaja, 2012).

The study, “Human health risk from Heavy metal (via food crops consumption) with wastewater irrigation practices in Pakistan,” was designed to investigate the potential human health risks associated with consumption of food crops contaminated with toxic heavy metals (Khan et al 2013). Cadmium (Cd) in surface soils and Cd, lead (Pb) and chromium (Cr) in the irrigation water and food crops samples were above permissible limits. All wastewater irrigated samples (soil and food crops) exhibited high relative contamination level as compared to samples irrigated with tube well water (Khan et al 2013). A comprehensive review on current status, of Arsenic (As) contamination in groundwater, with prominence of Pakistan Scenario has been reported by Ali et al. The biogeochemical processes mainly caused the dissolution of naturally occurring arsenic (As) into the groundwater sources. The oxidative process appeared to be the dominant process of As release into Pakistan aquifer. 11 districts in Sindh and Punjab provinces had As contamination in groundwater beyond the WHO and National quality standard level. The review also mentions numerous methods/processes in practice for As removal,

including the direct removal of As by converting As (III) to As (V) (Ali et al. 2018). Zia and Mehmood employing a quantitative method, recommend three main steps to be followed, (a) initial assessment of the site to be remediated, (ii) assessment of the exposure resulting from the site (including quantum of contaminants/contamination) and lastly (iii) remediation of the site (Zia and Mehmood 2018).

Findings & recommendations are summarized in the foregoing pages, of the research work carried out & reported in KP province, Federal Capital Islamabad, Sindh & Punjab provinces, searched through literature survey, mostly between 1990 - 2019.

KP Province and Islamabad

A study was carried out by Saif et al. (2005) for heavy metals accumulation in potentially contaminated soils of NWFP (presently KP) Province (48 soil samples) and the reported finding indicated that the concentrations of heavy metals were significantly high in soils irrigated with effluents. Highest heavy metal concentrations in the agricultural soils of the selected southern districts of Khyber Pakhtunkhwa (KP), were observed for Mn, Zn, Cr, Ni, and Cu by Rehman et al. The trend of metal transfer factors for different vegetables was in the order of Cu > Ni > Cr > Mn > Zn. (Rehman et al. 2018). A study to assess the heavy metal contamination of water (20 samples), was conducted in residential areas along the *Palosi* Drain, *Peshawar*, KP to assess heavy metal contamination (Cd, Pb, Ni, Cu, Fe, Zn and Mn). It was concluded that sub-surface drinking water quality was generally good and the contaminated wastewater did not affect the water quality of shallow wells (Ilyas & Sarwar 2002). Khan et al studied lead and cadmium contamination of different roadside soils and plants in Peshawar City, KP province and observed that long-term exposure to traffic caused the contamination of the roadside soils and plants with Pb and Cd. Significant variation ($P \leq 0.01$) in concentrations of Pb and Cd in soil and plant samples along primary, secondary and tertiary roads might be due to different traffic densities. (Khan et al 2011). Khan et al and Yuosafzai et al studied the impact of industrial discharges on the Quality of Kabul River Water at *Nowshera*, KP. Samples of effluents from different industries at *Amangarh* and the receiving Kabul River water were analyzed for various parameters. The results indicated localized pollution within half kilometer after the confluence point (Yousafzai et al 2008; Khan et al 1990). For the analysis of heavy metals such as Zn, Cu, Cd, Pb, Cr and Mn in River Kabul at Sardaryab , KP, water sampling was done at three locations of the River Kabul, at Shah Alam tributary. Pb, Cd and Cu contents in river water samples were found to be above, while the remaining heavy metals below the permissible limits (Amir et al 2017).

In NWFP (presently KP), a study was also conducted in 2001/2002 during summer and winter seasons to assess bioaccumulation of trace metals (Zn, Cu, Fe, Mn, Cd, Cr, Ni and Pb) by different plant species (44 samples), grown on potentially contaminated soils. The higher values were found in effluent irrigated plant tissues than tube-well irrigated plant tissues. The study recommended installation of treatment plants in the industrial area. (Haq et al. 2005). In view of the known toxicity, accumulative, persistent characteristics and adverse environmental and health impacts of DDT, an extensive survey of the soil (81 samples) was undertaken in and around a demolished DDT factory at *Nowshera*, NWFP, (presently KP), to examine DDT levels of the contaminated soil Analytical data indicated that 90.91% of the soil samples studied were contaminated with DDT, with 66.6% of the samples indicating residual DDT levels higher than DDT minimum risk level (MRL) in soil. For soil between the surface and at a depth of 0.60 m, the highest residual DDT level (5.78 ± 3.94 μg/g) was observed in samples from the

northwest direction. A follow up study showed that activated charcoal (AC) exhibited strong sorption of DDT in dry amended soil in laboratory conditions (Khwaja 2008; Jan et al. 2008; Younas et al 2009). In Abbottabad, KP, studies were carried out to analyze seasonal variation in the water quality of Salhad stream before and after the discharge of leachate from landfill situated at the bank of the stream. The study findings strongly suggested that landfill leachate (including Pb, Cd & Cu) had severe deleterious impact on the water quality of the stream. Integrated, multi-sector approaches and environmentally sound sustainable waste management have been recommended, to deal with the contamination problem due to the accumulated heterogeneous (hospitals, commercial & municipal) waste at the site, towards safeguarding public health in Salhad area (Maqbool et al 2011; 2012).

Muhammad et al. investigated the soil and wild plants of the Pb–Zn sulfide bearing mineralized zone of Indian plate (IP) in the *Pazang* and *Lahor sites* (unmineralized *Besham* zone as reference), Kohistan region. Soil and plants were analyzed for some major cations including Fe, Mn, Pb, Zn, Cd, Cu, Cr, Ni & Co (cobalt) contents. Soil and plants of the mineralized zone and surrounding areas have higher heavy metal (HM) contamination ($P < 0.01$) as compared to the reference site. Furthermore, in mineralized zones, the *Lahor* site was more contaminated than the Pazang site. The results also showed that plant species (*Plectranthus rugosus*, *Rumex hastatus*, *Fimbristylis dichotoma*, *Heteropogon conturtus* and *Myrsine Africana*) were the best heavy metal (HM) accumulators (Muhammad et al 2011). Health risks associated with heavy metals in the drinking water of Swat, has been studied and reported by Khan et al. Among the studied heavy metals, concentration for Cr were highest followed by Mn > Ni > Zn > Cd > Cu > Pb in the drinking water collected from both surface and groundwater sources in the study area. (Khan et al 2013). In agricultural soil of Swat district, heavy metal (HM) contamination was highest for Mn, followed by Ni > Cr > Cu > Zn > Cd. In 95% fruit and 100% vegetables samples, among the metals studied, Cd concentration was found higher than the WHO limit, 0.05 mg/kg (Khan et al. 2013). In Buner district, a study was conducted to investigate the presence of Cadmium (Cd) and Lead (Pb) in roadside soil and the cultivated vegetable Shalgham (Brassica Rapa). Soil and the vegetable samples were collected from primary, secondary, tertiary roadside fields and the control site. The study concluded that the studied samples of the vegetable Shalgham, taken from different roads side farms were contaminated with Pb and Cd (Rehman 2018).

Islamabad (Federal Capital)

Hydro-chemical groundwater investigations were conducted in the twin cities of Islamabad and Rawalpindi to examine the contamination of the ground water. Representative Ninety (90) sampling points, both open bore wells and tube wells, as well as Nallah Lei, were selected for collecting water samples. The quality of groundwater in Islamabad/Rawalpindi, except in the central area, was good and fit for human consumption and other uses. The ground water in the central part of Rawalpindi, i.e. cantonment area contained high amounts of nitrate, chloride, and sulfates, was of poor quality and may not be used for drinking purposes (Sajjad 1998). In a study at in Islamabad, the transfer, accessibility, and accumulation of metals (Pb, Cu, Zn, Co, Ni & Cr) from soil to roots and shoots were evaluated in terms of Bioaccumulation factor (BAF), Translocation factor (TF) and Bioaccumulation coefficient (BAC). Most species of plant accumulated higher concentration of Pb, Cu and Zn than the normal limits in shoots, Zn was relatively higher in grasses and Cu was highest in shoots. None of the plant species studied were recognized as hyper accumulator (Malik et al 2010). Iqbal and Shah studied the

distribution, correlation and risk assessment of selected metals in urban soils of Islamabad. The distribution and variation of the studied metals Cd, Co, Cr, Cu, Fe, Mn, Pb and Zn in soils, exhibited the seasonal variations, while multivariate analysis revealed significant anthropogenic pollution of metals in Islamabad urban soils samples. Degree of contamination was observed higher in the soils during winters (Iqbal and Shah 2011).

Sindh Province

Reduction of chromate by microorganisms isolated from metal contaminated sites of *Karachi*, Sindh was studied and reported by Badar et al. Three bacterial strains, isolated and identified from a foundry soil and a tannery, respectively, were found to be resistant to up to 1 mM chromate and anaerobically reduced Cr (VI). Overall, the tolerance to Cr (VI), of the isolates from the Cr contaminated sites could be potentially useful for bioremediation (Badar et al 2000). Earlier other studies have also indicated that the two P. stutzeri strains could bioaccumulate the copper compound - cupric carbide (Cu_2C). The main aim of the study entitled "Geochemical Baseline Determination and Pollution Assessment of Heavy Metals in Urban Soils of Karachi, Pakistan," was initiated to assess the pollution status of the urban soil through various geochemical and geo-statistical methods. Soils at some locations of Karachi were found to be enriched, moderately to moderately high with Pb, low to moderate chromium (Cr) & copper (Cu) and Zinc (Zn) had very low enrichment (Karim et al. 2014). A study to determine the concentrations of particulate matter with an aerodynamic diameter ≤10µm (PM10) and air transmitted particulate trace metals were carried out in ambient air of different areas in Karachi air (June 2011 - June 2012). Arithmetic means of 361.0µg/m³ was observed for PM10 in commercial areas, 275.0µg/m³ in residential areas, 438.0 µg/m³ in industrial areas and 68.9µg/m³ in urban background areas of Karachi. The average concentrations of Pb and Cd has also been reported (Hashmi et al 2017, 18 & 19)). In a recent study in Karachi, Sahar and Siddiqui investigated the eight heavy metals (Fe, Cu, Zn, Cr, Ni, Co, Pb, and Cd) occurrence, risk assessment in the sediment, sentinel crab (Macrophthalmus depressus) of the mangrove and the coastal environment. The environmental health and eco-toxicological profile of the habitat revealed high anthropogenic influences along the Karachi coast. Sediment-biota accumulation factor (SBAF) suggested active bioaccumulation (>1.0) in crabs for all metals, except Cr. Principal component analysis (PCA) concluded that environmental factors like seawater temperature, salinity, sediment grain size and organic matter had a significant association with different metal accumulation in crabs (Sahar and Siddiqui 2019).

Uzma et al. carried out a study on water quality in some selected areas of districts *Mirpurkhas* and *Larkana*. Research findings revealed arsenic content below WHO maximum permissible limit in *Mirpurkhas* areas. However, in Larkana district, 10% of the water samples of Larkana district exceeded the WHO guideline value (10ppb) for arsenic (Uzma et al 2006). Jakhrani et al carried out the determination of arsenic and other toxic metals in drinking water of *Khairpur* area in Sindh. In most of the water samples collected from hand pumps and tube wells, arsenic level was observed to be higher than WHO standard. Fe, Co, Cu, and Ni levels were also studied & reported in water samples from hand pump and the tube well. (Jakhrani et al 2009). Shahzad et al carried out a study wastewater samples (30) from industrial waste, cattle colony waste & domestic waste areas) and seawater (in front of Rehri Goth). Samples were collected at five sites along *Rehri* Creek (Sindh) and analyzed for different parameters, including heavy metals (Cr, Cu, Pb, Ni, As and Zn). The analytical data indicated that the concentration of heavy metals along the Creek was higher than earlier reported analytical data for the same. (Shahzad

et al 2009). A study conducted in *Badin* focused on physio-chemical assessment of water resources used for drinking purpose. Samples from 10 different sites of Badin city were collected and physio-chemical parameters, including heavy metals, were examined to assess water quality at the sampling sites. Water samples from the hand pumps in Laghari and Jamali villages were found to be contaminated, showing metallic contents of studied water samples, exceeding the WHO standards (Sanjrani et al. 2018).

Shah et al. carried out a study to determine the lead (Pb) distributions in blood and prevalence of elevated Pb exposure among children, age ranged (5–10 years), residing near industrialized region of *Hyderabad* city, Sindh. The results showed that significantly higher proportion of children living in the vicinity of industrial area, had blood lead levels (BLLs) higher than for those living in the non-industrial area. In the two studied areas, the blood BLL was also observed to be higher in boys as compared to girls of the same age group. Negative correlation was observed between BLLs and hemoglobin levels (Shah et al 2013). Study on organochlorine pesticides (OCPs) in surface soils from obsolete pesticide dumping sites in Hyderabad City was studied and reported by Alamdar et al. OCPs contamination levels in both matrices (soil & air) clearly showed, significant differences (p b 0.05) at the pesticide dumping ground as compared to the rest of the sampling sites. The higher concentration of OCPs (including DDT & HCH) in air samples correlated past and present usage of these compounds, in the vicinity of the soil sampling sites. The study report highlighted the potential risk to public health and environment due to OCPs and an urgent need for risk assessment of hazardous waste dumping sites and accordingly, control measures for the same (Alamdar et al. 2014).

Punjab Province

Jabbar et al. studied pesticide residues in cropland soils and shallow groundwater in the Punjab. The soils appeared to be loaded with the pesticide residues - a constant threat to public health and the environment (Jabbar 1993). Farooqi et al carried out a study to assess the sources of Arsenic (As) and Fluoride (F^-) in highly contaminated soils causing groundwater contamination in Punjab. Over 100 soil samples were analyzed and the results showed that the alluvial sediments contained low levels of fluoride (F^-) and the terrace soils contained high concentrations of soluble F^-. Infiltration of water from the surface into the shallowest groundwater seemed major cause of the contaminated groundwater in the area, while the structure of the aquifer could be another cause of the contaminated water in the area (Farooqi et al 2009).

Wastewater samples collected from the studied area in *Faisalabad* were analyzed in the laboratory for heavy metals & their concentrations and were compared with the critical levels of the metals in the edible portion of the vegetables (Najam & Nawaz 2015). Results showed that all wastewater samples had concentrations of lead and cadmium above WHO safe limit. The mean concentrations of lead and nickel were found to be higher than the safe limits in all the vegetables studied (Najam and Nawaz 2015). Ghafoor et al examined the chemical composition of effluents from different industries of the Faisalabad city. The quality of effluents from the Ghee and chemicals Mills were observed to be worse, compared to those from textile units and cereal grain processing industries. The concentrations of Fe, Mn, Cu, Zn, Pb and Ni were well below the safe limits in the effluents from all the sources as well as in the samples from both main drains in the area (Ghafoor 1994). Assessment of the characteristics of

wastewater/effluents from seven industries, was carried out in the city zone area of Faisalabad, by Hanif et al, including industrial units of ghee, Ni-Cr plating, battery, and tannery, textile (dying unit (DU) & finishing Unit (FU). The findings revealed that effluents from the all the studied industries were causing severe toxic metal pollution (Hanif et al. 2005). Another study carried out in Faisalabad, on heavy metals (Cd, Ni and Pb) contamination of soils, plants and waters was by Farid et al. Soil, plant and water samples were collected in the vicinity of Madina town, Faisalabad, following 4 × 4 Km grids. The results of the study showed different concentration of metals (Cd, Pb &, Ni) in soil samples at different depths, in plants & ground water. The concentration Pb and Ni was below the permissible limits while concentration of Cd in waters and plants was found to be above the permissible limits (Farid et al. 2015).

Qadir et al. carried out a study, to find the spatiotemporal changes in water quality of Nullah Aik, tributary of the *Chenab River*, not very far from Faisalabad. Stream/Nullah water samples were collected at seven sampling sites on seasonal basis from September 2004 to April 2006 and were analyzed for 24 water quality parameters. Most significant parameters which contributed to spatiotemporal variations were assessed statistically, identifying three different classes of sites: relatively unimpaired, impaired and less impaired sites/regions. Eight parameters (including Pb, Cr and Zn) accounted for 89.7% of total variations of spatial analysis. The results signified that parameters identified by statistical analyses were the cause for water quality changes (Qadir et al 2007). Adeel et al studied the human health risk assessment and dietary intake of organochlorine pesticides (OCPs) through air, soil and food crops (wheat & rice) along two tributaries of river Chenab. Among studied OCP isomers, DDTs and HCHs were found pre-dominant in the examined samples. The study strongly recommended that if the practice of wastewater irrigation and unplanned, indiscriminate pesticides dumping at sites continued, due to its hazardous chemical exposure, the risk to public health and cattle would likely become more threatening (Adeel et al 2014).

Farooqi et al. studied the toxic fluoride (F^-) and arsenic (As) contaminated groundwater in the *Lahore* and *Kasur* districts of Punjab and their possible release source/s. Five rainwater and 24 groundwater samples (from three different depths) were collected and analyzed. Shallow groundwater contained high F^- while the groundwater samples from the deeper depth were free from fluoride contamination. All groundwater samples contained high As content in excess of WHO drinking water standards (Farooqi et al 2007). The quality of wastewater from Rohi Nullah, Lahore was monitored for one year (2008-9) & evaluated, from those points where it was reported to be used for irrigation of crops cultivated at Nullah both sides. Wastewater was examined for cadmium (Cd), nickel (Ni), chromium (Cr), zinc (Zn), manganese (Mn), cobalt (Co) and copper (Cu). The concentration of Ni, Cr, Mn and Cu was observed above the FAO standards, while the concentration of Cd, Zn and Co fell within FAO standards. Considering NEQS standards, the metals concentration were within national standards limits. Temporal variations were prominent in some parameters and mostly higher values were observed in summer and lower in winter season. There was accumulation of heavy metals in soils receiving wastewater for irrigation. The metal contents in soils follow the order Mn> Co> Zn> Cr > Ni > Cu > Cd (Bashir et al 2014). Afzal et al studied the assessment of Heavy Metal Contamination in Soil and Groundwater at Leather Industrial Area of Kasur. In the study area of Kasur, where untreated leather industry effluents had been discharged for a long time, soil and groundwater were found to be contaminated with alarmingly high concentrations of various heavy metals (Cr, Fe, Ni, Cd, Pb, Zn, Co & Mn). Samples

were collected and analyzed for Cr, Fe, Ni, Cd, Pb, Zn, Co, and Mn. The data revealed that the collected samples of soil and groundwater in the study area, were highly contaminated with all tested heavy metals, chromium (Cr) in particular (Afzal et al 2014). Toxic metals contaminated land due to the use of discharged wastewater/effluents from the tanneries, can be effectively remediated with the indigenous fast-growing halophyte S. fruticose. The contaminated land, adjacent to Depalpur Road, Kasur, was rendered infertile, due to long term effluent logging from the leather industry. EDTA treatment resulted greater solubility of Cr in the soil pores containing water (Bareen and Tahira 2011).

The concentrations of total chromium (Cr) and its species - Cr (III) and Cr (VI), were assessed by Rafique et al. in soil, drinking water and effluents of tanneries (120 samples), in/around ten tannery clusters of *Sialkot* district. The concentration of total chromium, Cr (III), and Cr (VI) in wastewater, drinking water, and soil were above the Pakistan National Environmental Standard (NEQSs). It was found that pH above 6 leads to higher concentration of Cr (Vl) in-the studied samples (Rafique et al 2010). A study on surface soils through Hierarchical Cluster Analysis (HACA) in Sialkot indicated, the concentrations of Cd, Co, and Pb with traffic related activities and Cr, Cu, Ni and Zn either associated with automobiles or industrial activities. Spatial distribution maps exhibited relatively higher concentrations of Cd, Co, Cu, Ni, Pb, Cr and Zn along different traffic routes in the city. The results highlighted concentrations of Cd, Ni, Cr, Zn, and Pb measured in urban soil exceeded the permissible limit for surface soils (Malik et al 2010)**.** Ullah et al also carried out a study in Sialkot which was designed to assess the quality of groundwater (at 25 localities for 22 physiochemical parameters) in relation to heavy metal pollution and

its implication on human health. Cluster Analysis (CA) grouped all sites into four zones, based on spatial similarities and dissimilarities of physiochemical properties. The results revealed that the groundwater quality of

the studied localities/area could not be considered good, as it was highly turbid (57% of total localities/sites) with high level of Zn, and Pb which were above WHO and PSQCA permissible limits (Ullah et al. 2009).

In Sialkot, well-known for tanned leather/leather products production worldwide, a study was initiated by Qadir & Malik, to examine concentration of heavy metals (lead, cadmium, chromium and copper) in the liver, gills, kidneys and muscles of eight edible fish, in upstream and downstream zones of the Nullah Aik and Palkhu tributaries of the River Chenab, The pattern of metal accumulation in studied organs was in the order Cr>Pb>Cu>Cd and metal accumulation liver > gills > kidneys > muscles. Mean concentrations of Cd, Cr, and Cu were higher in pre-monsoon compared to post-monsoon season (Qadir & Malik, 2011). Tannery-affected surface soils from 72 sampling sites in the industrial area of Sialkot district, were collected and analyzed for nine physicochemical parameters, nine heavy metals, and four macro-nutrients (Ali et al 2015). The results showed that concentration of heavy metals followed the order: Cr<Fe<Ni<Mn<Cu<Zn<Co<Pb<Cd. Ecological risk index (ERI) showed high potential ecological risk associated with Cd and Cr with mean concentrations above respective average shale/background values. The results could contribute as reference/guidance to monitoring programs at regional levels (Ali et al 2015). Another study carried out by Junaid et al in Sialkot industrial sector, showed the increasing heavy metal pollution especially in the blood, urine, and hair samples of the exposed workers and in indoor dust samples. The heavy metals Cr, Ni, Cd, and Pb were identified as

the main pollutants. Shivering/crusting, cutting, and stitching of leather were highlighted as the highest heavy metals contributing unit operations/factory sections. Results also indicated that the level of Cr in indoor industrial dust was more than twice, compared to the background household dust and Cr (VI) exhibited higher cancer risks than that of Cd in the exposed workers (Junaid et al 2017).

Zahir et al. carried out a study to examine the concentrations of arsenic (As), chromium (Cr) and lead (Pb)at 20 different localities in drinking water (tube-well, filter plant, hand pump & tap water) of district *Sahiwal*. The levels of As and Pb were lower than Pakistan NEQSs while Ch was observed to be above NEQS in all the studied water samples (Zahir et al 2015). Study was also carried out to evaluate the impact of untreated urban and industrial effluents on Ravi river water quality. Water samples were collected from 11 polluted and relatively unpolluted sites, along the river, during low flow season and analyzed for heavy metals (Mn, Pb, Ni, Zn & Cd) contents and selected Physico-Chemical parameters. At several polluted sites along the river, manganese (Mn) and lead (Pb) contents were higher than permissible limits, for aquatic ecosystems. Findings revealed that river water at downstream sites of wastewater, from the drains, was not suitable to fish growth and other aquatic lives (Shafi 2018). A recent study at Sharaqpur, *Sheikhupura* district (20 sites), was carried out by Riaz et al (2019), to assess the magnitude and human health impacts of heavy metals (Cd, Cr and Ni) presence in drinking water. Health risk assessment through Chronic Daily Intake (CDI), oral exposure, health quotient, health of children and adults was assessed. Detailed chemical analyses results showed that Nickel (Ni) and Cadmium (Cd) concentrations in drinking water were higher than the permissible limits of WHO and NEQSs, at most of the sampling sites in the study area. However, Chromium (Cr) content was found to be within acceptable limit. Health risk assessment determined the chronic impacts in order Cd>Ni>Cr. (Riaz et al 2019). For *Rawalpindi* region, a study was conducted by Mushtaq & Khan, to evaluate the characteristics of effluents/wastewater used for irrigation purpose and also to elucidate impacts on heavy metals (Ni, Pb, Cd, Cu, & Cr) contents, in the soils of the study area. Results indicated that among others, Cadmium (Cd) and Chromium (Cr) contents were above the critical limits in almost all the effluent samples. On the basis of research findings, it was concluded that the studied effluents/wastewater samples, collected from different locations of Rawalpindi, were not good for irrigation and crops production (Mushtaq & Khan 2010)

From the above account of the reported research carried out in Pakistan, the potential threat to environment and risk to public health, resulting from toxic pollutants/hazardous waste sites is most evident. Several tried, tested & reported methodologies/technologies (including ones described above) are available, to be further assessed and used, for detoxification/decontamination of polluted water, soil & land in the country (Khwaja 2020).

(Acknowledgement: Support of Ms. Qurratulain, SDPI Hazardous Wastes/Sites Research team, towards literature survey, is thankfully acknowledged and appreciated.)

REFERENCES

Afzal, M., Shabir, G., Iqbal, S., Mustafa, T., Khan, QM. & Khalid, ZM 2014, "Assessment of heavy metal contamination in soil and groundwater at leather industrial area of Kasur, Pakistan," *CLEAN–Soil, Air, Water*, *42*(8), 1133-1139

Ahad, K., Mohammad, A., Khan, H., Ahmad, I. & Hayat, Y 2010, "Monitoring results for organochlorine pesticides in soil and water from selected obsolete pesticide stores in Pakistan," *Environmental monitoring and assessment*, *166*(1-4), 191-199

Alamdar, A., Syed, J. H., Malik, R. N., Katsoyiannis, A., Liu, J., Li, J., Zhang, G. and Jones, K. C. (2014). "Organochlorine pesticides in surface soils from obsolete pesticide dumping ground in Hyderabad City, Pakistan: contamination levels and their potential for air–soil exchange," *Science of the total environment*, *470*, 733-741

Ali, W., Rasool, A., Junaid, M. & Zhang, H. (2018) "A comprehensive review on current status, mechanism, and possible sources of arsenic contamination in groundwater: a global perspective with prominence of Pakistan scenario,". *Environmental geochemistry and health*, 1-24

Ali, Z., Malik, R. N., Shinwari, Z. K., & Qadir, A. (2015) "Enrichment, risk assessment, and statistical apportionment of heavy metals in tannery-affected areas," *International Journal of Environmental Science and Technology*, *12*(2), 537-550.

Uzma, A, U., Perveen, F., Alvi, S., Khan, F. A., Siddqui, I. & Usmani, T. H. (2006) "Contamination of Arsenic in Public Water Supply Schemes of Larkana and Mirpurkhas districts of Sind," J. Chemical Society of Pakistan, *28*(2), 130 - 35.

Amir, A., Usman, K., Rehman, HU, Khudadad, S, Munawar, A, Rab, A, Khan, MA, Gul, M & Pervaiz, K 2017, "Analysis of heavy metals in river Kabul at Sardaryab Khyber Pakhtunkhwa, Pakistan," J. Entomology and Zoology studies, 5(6), pp14-16

Khan, AU 2010, "Evaluation of Industrial Environmental Management – Pakistan," May

Badar, U, Ahmed, N, Beswick, A. J., Pattanapipitpaisal, P. & Macaskie, L. E. (2000) "Reduction of chromate by microorganisms isolated from metal contaminated sites of Karachi, Pakistan,"*Biotechnology letters*, *22*(10), 829-836.

Bareen, FE & Tahira, SA 2011, "Metal accumulation potential of wild plants in tannery effluent contaminated soil of Kasur, Pakistan: field trials for toxic metal cleanup using Suaeda fruticose," *Journal of hazardous materials*, *186*(1), 443-450.

Bashir, F., Tariq, M., Khan, R. A. & Shafiq, T. (2014) "Quality of wastewater used for conventional irrigation in the vicinity of Lahore and its impact on receiving soils and vegetables," *Pakistan Journal of Scientific & Industrial Research Series A: Physical Sciences*, *57*(2), 86-94.

Farid, G, Sarwar, N, Saifullah, AA, Ghafoor, A & Rehman, M 2015, "Heavy Metals (Cd, Ni and Pb) contamination of soils, plants and waters in Madina Town of Faisalabad Metropolitan and preparation of Gis Based Maps," *Adv Crop Sci Tech*, *4*(2).

Farooqi, A, Masuda, H, Siddiqui, R & Naseem, M 2009, "Sources of arsenic and fluoride in highly contaminated soils causing groundwater contamination in Punjab, Pakistan," *Archives of environmental contamination and toxicology*, *56*(4), 693-706

Farooqi, A., Masuda, H., & Firdous, N 2007, "Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. *Environmental Pollution*," *145*(3), 839-849.

Ghafoor, A., Rauf, A., Arif, M. & Muzaffar, W. (1994) "Chemical composition of effluents from different industries of the Faisalabad city," *Pak. J. Agri. Sci*, *31*(4).

Haq, M-Ul, Khattak, R.A., Puno, H.K., Saif, M.S., Memon, K.S.and Sial, N. B. (2005) "Bioaccumulation of trace elements by different plant species grown on potentially contaminated soils of NWFP, Pakistan," *Asian Journal of Plant Sciences*, *4*(4), 383-387.

Hanif, M. A., Nadeem, R., Rashid, U. & Zafar, M. N. (2005) "Assessing pollution levels in effluents of industries in city zone of Faisalabad, Pakistan," *Journal of Applied Science*, *5*(10), 1713-1717

Hashmi, D. R., Shareef, A., & Khan, F. A. (2017), "The Study of PM10 Concentration and Trace Metal Content in Different Areas of Karachi, Pakistan," *Pakistan Journal of Scientific & Industrial Research Series A: Physical Sciences*,*60*(1), 50-58.

Hashmi, M.A., Kumar,V. & Varma, A. (2017) Xenobiotics in the Soil Environment: Monitoring, Toxicity and Management. ISBN: 978-3-319-47743-5.Volume 49, Soil Biology Series. Springer International Publishing Switzerland, DOI: 10.1007/978-3-319-47744-2

Hashmi, M.A., Varma, A. 2019. Electronic Waste Pollution: Environmental Occurrence and Treatment Technologies. ISBN: 978-3-030-26614-1.Volume 57.Soil Biology Series. Springer International Publishing Switzerland, DOI: 10.1007/978-3-030-26615-8

Hashmi, M.Z, Varma, A. (2018). "Environmental Pollution of Paddy Soils," ISBN: 978-3-319-93670-3.Volume 53, Soil Biology Series. Springer International Publishing Switzerland, DOI: 10.1007/978-3-319-93671-0

Ilyas, A. & Sarwar, T. (2002) "Study of trace elements in drinking water in the vicinity of Palosi drain, Peshawar," *Pak J Biol Sci*, *6*, 86-91

Iqbal, J. & Shah, M. H. (2011) "Distribution, correlation and risk assessment of selected metals in urban soils from Islamabad, Pakistan," *Journal of hazardous materials*, *192*(2), 887-898

Jabbar, A., Masud, S. Z., Parveen, Z. & Ali, M.(1993) "Pesticide residues in cropland soils and shallow groundwater in Punjab Pakistan, *Bulletin of environmental contamination and toxicology*, *51*(2), 268-273.

Jakhrani, M. A., Chaudhray, A. J., Malik, K. M., Mazari, M. Q., & Jakhrani, A. A. (2009) "Determination of arsenic and other heavy metals in hand pump and tube-well ground water of Khairpur, Sindh, Pakistan," *2009 Second International Conference on Environmental and Computer Science* (pp. 271-276). IEEE.

Jan, M. R., Shah, J., Khawaja, M. A. & Gul, K. (2008) "DDT residue in soil and water in and around abandoned DDT manufacturing factory," *Environmental monitoring and assessment, 155*(1-4), 31-38.

Junaid, M., Hashmi, M. Z., Tang, Y. M., Malik, R. N., & Pei, D. S. (2017)" Potential health risk of heavy metals in the leather manufacturing industries in Sialkot, Pakistan," *Scientific reports, 7*(1), 8848.

Khan, A. R., Akif, M., Khan, M., & Riaz, M. (1999) "Impact of Industrial discharges on the quality of Kabul River water at Amangarh, Nowshera (Pakistan)," *Jour. Chem. Soc. Pak. Vol, 21*(2).

Khan, M.B. (2001), "National Report – Pakistan", Hazardous Waste Management: Policies and Practices in Asian Countries," Asian Productivity Organization, Tokyo, Japan pp 155 - 205

Khan, S., Rehman, S., Khan, A. Z., Khan, M. A., & Shah, M. T. (2010) "Soil and vegetables enrichment with heavy metals from geological sources in Gilgit, northern Pakistan," *Ecotoxicology and environmental safety*, *73*(7), 1820-1827

Khan, S., Khan, M. A., & Rehman, S. (2011) "Lead and cadmium contamination of different roadside soils and plants in Peshawar City, Pakistan," *Pedosphere, 21*(3), 351-357.

Khan, K., Lu, Y., Khan, H., Zakir, S., Khan, S., Khan, A. A. & Wang, T. (2013) "Health risks associated with heavy metals in the drinking water of Swat, northern Pakistan," *Journal of environmental sciences, 25*(10), 2003-2013.

Khan, K., Lu, Y., Khan, H., Ishtiaq, M., Khan, S., Waqas, M & Wang, W.U., (2013) "Heavy metals in agricultural soils and crops and their health risks in Swat district, northern Pakistan," *Food and chemical toxicology, 58,* 449-458.

Khan, M. U., Malik, R. N., & Muhammad, S. (2013) "Human health risk from heavy metal via food crops consumption with wastewater irrigation practices in Pakistan," *Chemosphere, 93*(10), 2230-2238.

Karim, Z., Qureshi, B. A. & Mumtaz, M. (2014)"Geochemical baseline determination and pollution assessment of heavy metals in urban soils of Karachi, Pakistan," *Ecological Indicators, 48,* 358-364.

Khwaja, MA 2003, "Lead exposure and children: Blood lead levels in school children resulting from leaded petrol use and increasing road traffic in Pakistan," Policy Paper Series #31Sustainable Development Policy Institute (SDPI), Islamabad Pakistan; ibid- (2005) Science Technology & Development, vol. 24, no. 2, pp. 1-5

Khwaja, MA 2008, "POPs Hot Spot: Soil Contamination due to a Demolished Dichlorodiphenyltrichloroethane (Persistent Organic Pollutant) Factory, Nowshera, NWFP, Pakistan," *Annals of the New York Academy of Sciences, 1140*(1), 113-120.

Khwaja, M.A. (2012), Sustainable Development Policy Institute (SDPI), Islamabad. Pakistan. (Private Communication)

Khwaja, MA 2012, "Environmental Challenges and Constraints to Policy issues for Sustainable Industrial Development in Pakistan," SDPI 20th anniversary special publication, "*Environment, Trade and Governance for Sustainable Development*," Sustainable Development Policy Institute, Islamabad. Pakistan. pp 13-18

Khwaja, MA 2016, "Waste Management in Pakistan," SDPI News and Research Bulletin," 23 (2) Sustainable Development Policy Institute (SDPI), Islamabad, Pakistan

Khwaja, MA 2020, "Poisons in Our Environment," Sustainable Development Policy Institute, Islamabad. Pakistan pp 108

Mahmood, A., Malik, RN, Li, J & Zhang, G 2014, "Human health risk assessment and dietary intake of organochlorine pesticides through air, soil and food crops (wheat and rice) along two tributaries of river Chenab, Pakistan," *Food and chemical toxicology, 71*, 17-25.

Malik, RN, Jadoon, WA & Husain, SZ 2010, "Metal contamination of surface soils of industrial city Sialkot, Pakistan: a multivariate and GIS approach," *Environmental geochemistry and health, 32*(3), 179-191.

Malik, R. N., Husain, S. Z. & Nazir, I. (2010), "Heavy metal contamination and accumulation in soil and wild plant species from industrial area of Islamabad, Pakistan" *Pak J Bot, 42*(1), 291-301.

Maqbool, F., Malik, A. H., Bhatti, Z. A., Pervez, A. & Suleman, M. (2012) "Application of regression model on stream water quality parameters," *Pakistan Journal of Agricultural Science, 49*(1), 95-100.

Muhammad, S., Shah, M. T. & Khan, S. (2011) "Heavy metal concentrations in soil and wild plants growing around Pb–Zn sulfide terrain in the Kohistan region, northern Pakistan," *Microchemical Journal, 99*(1), 67-75.

Mushtaq, N. & Khan, K. S. (2010)"Heavy metals contamination of soils in response to wastewater irrigation in Rawalpindi region," *Pak. J. Agri. Sci, 47*(3), 215-224.

Najam, S., Nawaz, R., Ahmed, S., Ehsan, N., Khan, M.M. and Nawaz, M.H. (2015). "Heavy Metals Contamination of Soils and Vegetables Irrigated with Municipal Wastewater: A Case Study of Faisalabad, Pakistan," J. Environmental and Agricultural Sciences, 4, pp. 6 - 10

Prasad, P and Khwaja, M.A. (2011), "Hazardous Wastes in Asian Pacific Region," Rev. Environ Health, 26(1) pp 31- 38

Qadir, A., Malik, R. N. & Husain, S. Z. (2007) "Spatio-temporal variations in water quality of Nullah Aik-tributary of the river Chenab, Pakistan.,"*Environmental Monitoring and Assessment*,"*140*(1-3), 43-59.

Qadir, A. & Malik, R. N. (2011) "Heavy metals in eight edible fish species from two polluted tributaries (Aik and Palkhu) of the River Chenab, Pakistan," *Biological Trace Element Research, 143*(3), 1524-1540.

Rafique, U., Ashraf, A., Khan, A. K., Nasreen, S. & Rashid, R. and Mehmood,Q, (2010) "Toxic chromium from tanneries pollute water resources and soils of Sialkot (Pakistan)," *Journal of the Chemical Society of Pakistan, 32*(5), 644-649.

Rehman, Z. U., Sardar, K., Shah, M. T., Brusseau, M. L., Khan, S. A., & Mainhagu, J. (2018), "Transfer of heavy metals from soils to vegetables and associated human health risks at selected sites in Pakistan," *Pedosphere, 28*(4), 666-679.

Rehman, M.U., Khan, M.A., Shah, W & Naz , A. (2018) "Assessment of Roadside Soil and Brassica Rapa Contamination by Heavy Metals in Buner district, Pakistan," BIOLOGIA (Pakistan), 64 (1), pp 93 - 99

Saher, N. U. & Siddiqui, A. S. (2019) "Occurrence of Heavy Metals in Sediment and their Bioaccumulation in Sentinel Crab (Macrophthalmus depressus) from Highly Impacted Coastal Zone," *Chemosphere*

Saif, M. S., Suleman, M. K., & Sial, N. B. (2005) "Heavy metals accumulation in potentially contaminated soils of NWFP," *Asian Journal of Plant Sciences*, *4*(2), 159-163

Shafi, J., Mirza, Z. S., Kosour, N., & Zafarullah, M. (2018) "Assessment of Water Quality and Heavy Metals Contamination of River Ravi in Pakistan," *Pakistan Journal of Analytical & Environmental Chemistry*, *19*(2), 169-180

Shah, F, Kazi, TG, Afridi, HI, Khan, N, Brahaman, KD, Arain, SS & Arain, SA 2013, "Assessment of lead in blood samples of children residing in the vicinity of industries," *Pakistan Journal of Analytical & Environmental Chemist,"14*(1), 9

Shahzad, A, Khan,MA, Shaukat, SS & Ahmed, W 2009, "Chemical pollution profile of Rehri creek area, Karachi (Sindh). *Journal of the Chemical Society of Pakistan"*, *31*(4), 592-600

Sajjad, M., Rahim, S. & Tahir, S. S. (1998) "Chemical quality of groundwater in Rawalpindi/Islamabad, *WEDC Conference,"* Vol. 24, pp. 271-274, Water Engineering and Development Centre

Sanjrani, M.A., Talpur, H.A & Talpur, S.A. (2018). "Physio-Chemical Assessment of Water Sources for Drinking Purpose

in Badin City, Sindh Province, Pakistan, (Water Supply Schemes and Hand Pumps)"

Ullah, R., Malik, R. N. & Qadir, A. (2009) "Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan," *African Journal of Environmental Science and Technology*, *3*(12)

Younas, A., Hilber, I., Khwaja, M.A. and Bucheli, T.D. (2009), "Evaluation of activated carbon amendment for reclamation of a DDT contaminated site in Pakistan,". 13th international conference, The Pacific Basin Consortium (PBC) for environment and Health, Perth, Australia; -ibid- , Rehman, S. (2012), "Former DDT factory in Pakistan revisited for remediation: severe DDT concentration in soils and plants from within the area," Environmental Science and Pollution Research", DOI 10.1007/s11356-012-1317-y

Yousafzai, A. M., Khan, A. R., & Shakoori, A. R. (2008) "An assessment of chemical pollution in River Kabul and its possible impacts on fisheries," *Pakistan Journal of Zoology*, *40*(3), 199

Zahir, M.,Tufail, S., Mehmood, K & Ahmad, F. (2015). "Evaluation of arsenic and other toxic metals in drinking water of Sahiwal district, using different spectroscopic techniques," 27 (5), 4239 - 4244

Zia, M. Q., & Mehmood, M. (2018), "Integration and Analysis of Resource Inventory Data for Risk Assessments of Environmental Contamination in Mixed Use Landscapes in Pakistan," MPRA paper No. 85510, pp 1-14

Sustainable Development Policy Institute
Taimur Chambers, First Floor, 10-D (West) Fazal ul Haq Road, Blue Area, Islamabad
Tel: +92 512278134, +92 512278135, Email: main@sdpi.org, www.sdpi.tv