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Geo-spatial assessment of tap water and air quality in Gilgit city using geographical information system

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Abstract

Water and life are two sides of the same coin, since water sustains all life processes. The quality of water is of vital concern for mankind since it is directly linked with human health and environmental protection. This study focuses on mapping the quality of tap water using Geographical Information System (GIS) software. Thematic maps were generated on 1:50,000 scale using ArcGIS 10.1. The interpolation pattern of water quality is showing that the pH of Gilgit city was slightly acidic to slightly alkaline with normal electric conductivity. The minimum to maximum range of other water parameters was recorded as 7.22-7.58 calcium hardness, 3.45-96.41 calcium, 0.35-30.8 magnesium, 2.46-5.12 potassium, 1.525-4.09 sodium and 59.47-65.4 mg/l TDS while *E. coli* 16.0-225.94 CFU/l of water were recorded. The dispersion of air pollutants have shown interesting results and range of air quality parameter were recorded as carbon monoxide; 0.47-1.13 mg/m^3, NO_2 380.0-590 μg/m^3, PM_{10} 88.96 164.48 ug/m^3 and hydrocarbons 3.7- 4.89.

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Introduction

Water is one of the best gifts to all living creature, given by the nature. It is compulsory for the growth and maintenance of human body and also for many biological activities (Singh and Saharan, 2010). It plays a vital role for the survival of all forms of life on earth and works as a universal solvent (Mishra *et al.*, 2008). Pure water is an essential resource for life. Man uses it for different purposes like drinking, washing, in agriculture, food processing and in other applications.

Good quality of drinking water is essentially needed for all the people throughout the world (Farah *et al.*, 2002). The best quality potable water free from hazardous materials and contaminants must be available for the public to avoid disease incidence and it is also used as a powerful environmental tool, required to determine the health of public. Good quality drinking water means keeping away public from dangerous water related diseases6.

Superior quality of water not only enhances human productivity but also add bonus days to the human life (WHO, 2006; WSP, 2009; Urbansky, 2002). Water is one of the most essential natural resources for eco-sustainability and is likely to become critical scarce in the coming decades due to increasing demand, rapid growth of urban populations, development of agriculture and industrial activities especially in semi-arid regions (Hajalilou and Khaleghi, 2009). Variations in availability of water in time, quantity and quality can cause significant fluctuations in the economy of a country. Hence, the conservation, optimum utilization and management of this resource for the betterment of the economic status of the country become paramount (Singh *et al.,* 2009). The definition of water quality is very much depending on the desired use of water.

Therefore, different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis (Khodapanah *et al.,* 2009). On the other hand, GIS is very helpful tool for developing solutions for water resources problems to assess in water quality, determining water availability and understanding the natural environment on a local and / or regional scale. From GIS, spatial distribution mapping for various pollutants can be done. The resulting information is very useful for policy makers to take remedial measures (Swarna Latha and Nageswara Rao, 2010).

Materials and methods

Study Area

The study area is Gilgit city (Fig. 1), which is the Northern part of Pakistan. Gilgit is the capital city of the province of Gilgit-Baltistan. It is the administrative and commercial centre of the Gilgit-Baltistan. It is situated in the foot hills of the Karakorum mountain range, at 35.9221 longitudes, 74.3087 latitude, and at an average altitude of 1,500 m (5,000 ft). The city is surrounded by steep vertical mountains 500m to 1500m (height of the mountain is between 2000m to 3000m (Google Maps).

Air Quality and Water Pollution

Input Datasets

The boundary of the Gilgit city is digitized from the Satellite image (Landsat TM) Landsat image 2000-05-14 were acquired from the USGS website to serve the purpose.

Development of Base Map

The images were _geo-referenced‘, mosaicked and subset by using geo-referenced shape files of Gilgit-Baltistan. The roads, river and each location of water sample digitized manually from the Arc-GIS 10.1 base map. The shape files and Location of Sampling station map of research or study region has been ready via utilizing Arc-Map 10.1. The parameters of water quality such as calcium hardness, pH, total dissolved solids etc were obtained from LG&RD (Annual Report 2012) Department Gilgit-Baltistan and from paper Pak j food sci2009 , 19(1-4):36-39.

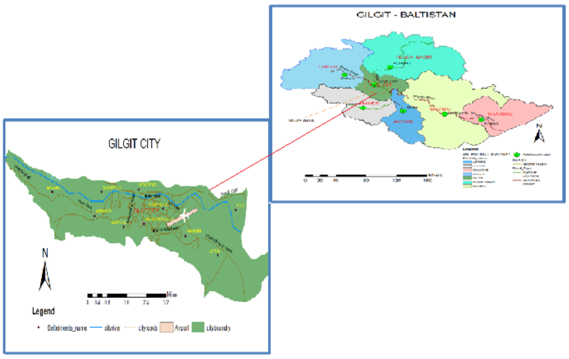

Fig. 1. Map of study Area.

Results

Spatial Distribution of Water quality parameters

Hydrogen Ion Concentration (pH)

Spatial distribution of pH in the study revealed that highest concentration of pH was in Konodas and low concentration of pH in KIU water sample (Fig 2).

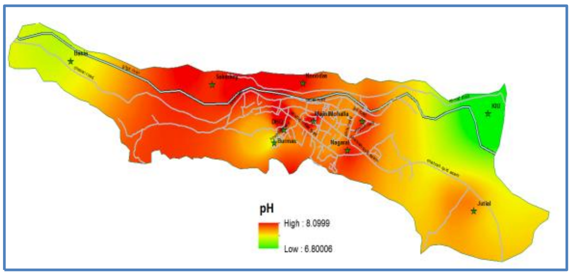

Fig. 2. Spatial distribution of water pH.

Electrical Conductivity (EC)

Electrical conductivity ranged from 78.0048 to 607.953 µm/ml. However, high concentration of electrical conductivity has been examined in Sakarkoy and low concentration of electrical conductivity observes in Basin (Fig 3).

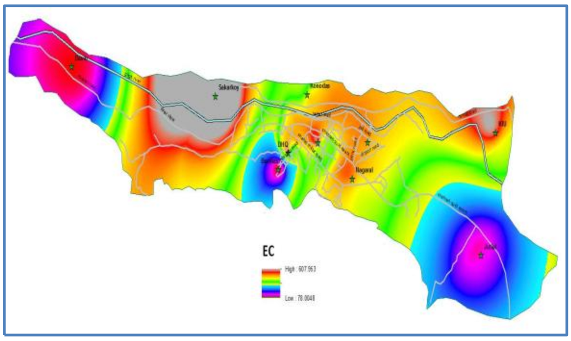

Fig. 3. Spatial distribution of water electric conductivity.

Calcium Hardness

Spatial distribution of the water hardness in drinking water of the study region and it differ/varies between 7.22 to 7.58 mg/l. Low percent ration of calcium hardness was found in Majini Mohallah which lies in the center of study area and higher concentration of C.Hardness was found in Konodas (Fig 4).

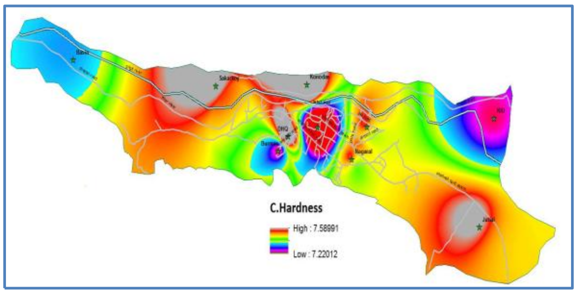

Fig. 4. Spatial distribution of water calcium hardness.

Calcium

Calcium contents in the drinking water of the study area, which ranges from 3.45- 96.41mg/l. The high concentration of calcium was found in Burmas area and low concentration was found in Jutial area of the study region (Fig 5).

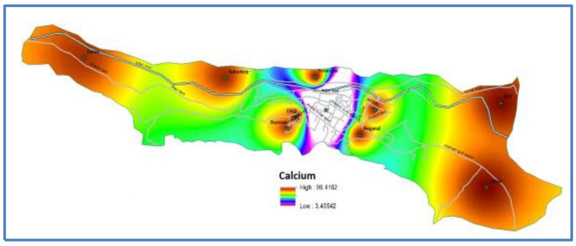

Fig. 5. Spatial distribution of calcium.

Magnesium

Spatial distribution of magnesium fluctuates between 0.356 to 30.8005 mg/l whereas high concentration was found in Konodas and low in Barmas (Fig.6).

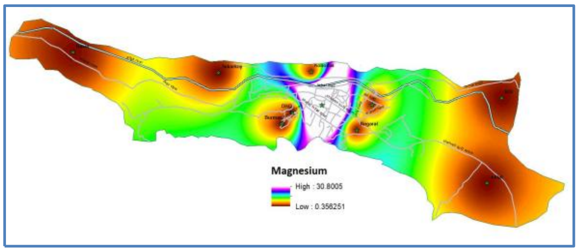

Fig. 6. Spatial distribution of magnesium.

Escherichia coli

E. coli spatial distribution in the drinking water of the study region vary in between 16.0063 to 225.947 per/l. High concentration of *E. coli* was found in Majini Mohallah and low concentration was found in Burmas (Fig 7).

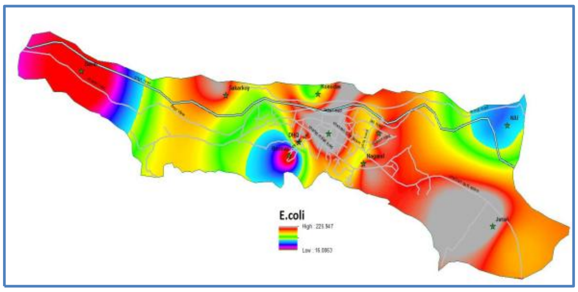

Fig. 7. Spatial distribution of *E. coli*.

Potassium

Potassium contents of drinking water range from 2.46-5.125 mg/l. However lowest concentration was found in DHQ Gilgit and high concentration in Jutial (Fig 8).

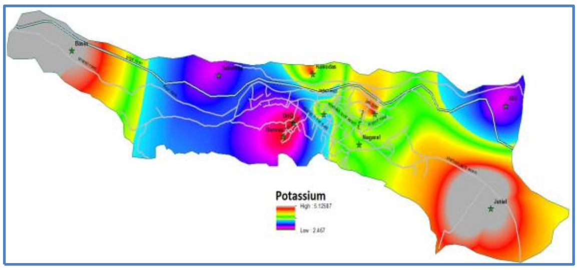

Fig. 8. Spatial distribution of calcium hardness.

Sodium

Spatial distribution of sodium in the drinking water of the study range from 1.525 to 4.09444 mg/l. Low concentration was recorded in Burmas and high in Kashrote area (Fig 9).

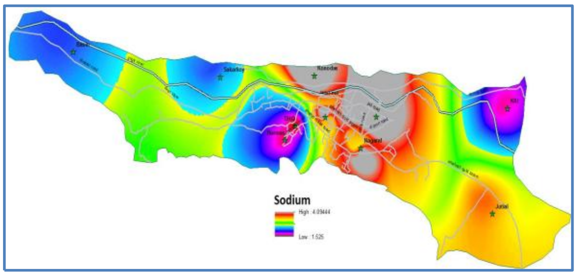

Fig. 9. Spatial distribution of sodium.

Total Dissolved Solids (TDS)

TDS variable between 59.4725-65.4 mg/l. Low concentration of TDS was found in Sakarkoy and high concentration in Burmas (Fig10).

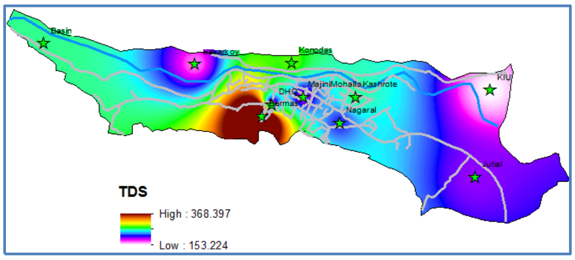

Fig. 10. Spatial distribution of TDS.

Turbidity

Spatial distribution of turbidity in the drinking water of the study region and it fluctuate/varies in between 3.90405 to 24.9921 mg/l. low concentration of turbidity was found in Konodas area and high concentration was found in Majini Mohallah (Fig 11).

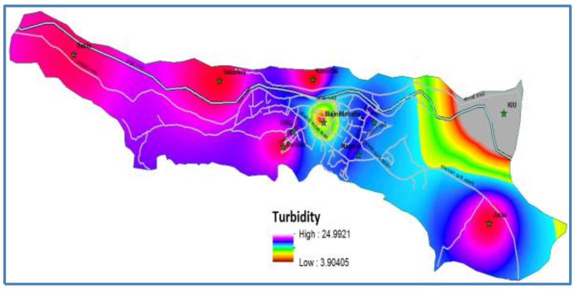

Fig. 11. Spatial distribution of turbidity.

Spatial Distribution of Air Quality Parameters

Carbon Monoxide (CO)

Spatial distribution of carbon monoxide in study region showed that minimum CO was 0.47002 mg/m3, at Khomar Chowk Gilgit, whereas it was found highest at 1.13 mg/m3 at Hospital chowk (Fig12).

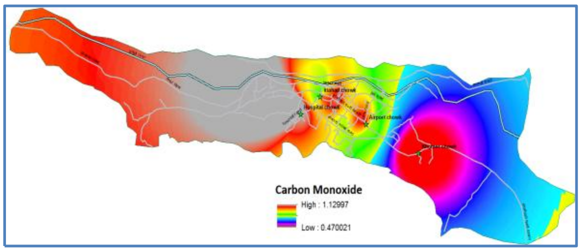

Fig. 12. Spatial distribution of air CO.

Oxides of Nitrogen (NO2)

The results of concentration of NO2 are ranging from 380.009 µg/m3 minimum at Khomer Chowk till maximum of 590 µg/m3 at Ithad chowk and Hospital chowk (Fig.13)

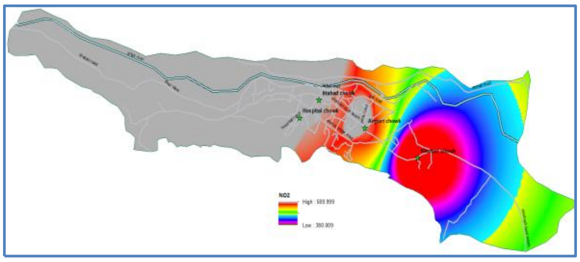

Fig. 13. Spatial distribution of air NO_2.

Particulate Matter (PM10)

Spatial distribution of Particulate matter in the study area showed variation in concentration of PM10 from 88.96 to 164.487 µg/m^3. The minimum average PM10 level was registered 88.95 µg/m3 at Airport Chowk Gilgit. Whereas it was found highest 168.5 µg/m3 at Ittahad chowk (Fig 14).

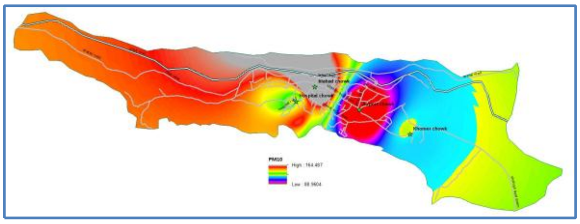

Fig. 14. Spatial distribution of air PM_{10}.

Hydrocarbons

The concentration of hydrocarbons in the air monitored for each selected location of Gilgit. The results of concentration indicate that hydrocarbons is ranging from 3.700 minimum at Airport Chowk till maximum of 4.899 at Ithad chowk (Fig15).

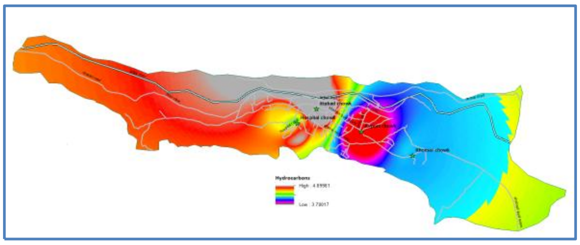

Fig. 15. Spatial distribution of air hydrocarbon.

Discussion

Water Quality

Water quality is significant considering that it is the major issue determining its appropriateness for drinking. The following parameters of water quality namely; pH, EC, *E. coli*, turbidity, TDS, Ca, Na and Mg were choose and their particular maps were ready using secondary data for geospatial analysis. Although pH (hydrogen ion concentration) has no straight/direct impact on consumer but it is essential parameter to verify water quality. The range of pH in our current study is 6.8-8.0. This pH ranged with the permissible limits as given by World health organization. The electric conductivity of drinking water is due to dissolved salt in water the range of electric conductivity in current study is 78-608 which indicates that the E.C is good range for drinking in our study area. Electrical conductivity (EC) is the estimate of water tendency to outdo electric current through it. It shows the total amount of melt salts. Electrical conductivity values for drinking water depends on the absorption of ionic particles and dissolved salts through which electric current passes, it will be high with more electrolytes in water (Wright and Mason, 1996). According to WHO, (1997) ; EPA, (1997) high turbidity cause problems of purification and increase treatment expenses so the turbidity must not exceed 5 NTUs and water having less than 1.00 NTUs is excellent for domestic consumption. Total dissolved salts in water are presence of weight of residues left in water after evaporation. It is composed of inorganic and small amount of organic constituents. The organic salt principally contains calcium, magnesium, potassium, sodium, bicarbonate and chloride. In our study area TDS range in 59.46-65.45 which fall admissible limit according to WHO and ISI (mg/l) standards. TDS more than admissible limits (500 mg/l) is undesirable for drinking and many industrial uses. High TDS change taste of drinking water (Durf and Baker, 1964). Jain *et al.*, 2003 stated that high contents of TDS cause gastrointestinal problems. Ramesh and Elango, 2006 stated that water hardness above 200mg/l may cause scale development in the supply system. The elevated solidity/hardness of 150-300mg/l and higher than might cause heart diseases and kidney problems while high concentrations of magnesium and calcium are also increase waters hardness (Al-Ahmadi and El-Fikey, 2009). Chloride is minor constituent of the earth‘s crust. Rain water contains less than 1 ppm Chloride. In drinking water chloride originates from natural sources, industrial effluents and sewage, urban runoff including saline intrusion and de-icing salt (WHO, 1993)

Air Quality

Spatial distribution of air quality in Gilgit-city using GIS approach. Concentration of

PM10, hydrocarbon (HC), nitrogen dioxide and carbon monoxide (CO) were ranged in 88.95-116.74), (3.7-4.9), (380-590) and (0.47-1.13) µg/m3 respectively. PM10 composed of extremely small solid and liquid particles which are floating in the air. Particles of PM10 are < 10 microns in diameter which is a main constituent of air contamination or pollution that threatens both our environment and our health. All over the world air pollution is major of concern of public health. Different studied in worldwide revealed that air pollution especially gaseous pollutants and particulate matter can cause cardio-vascular, respiratory diseases and cardio-pulmonary mortality (Koken *et al.*, 2003; Dockery *et al.*, 1993). It had observed that motor vehicle, population growth, petrol and diesels engines of motor vehicles were found to release a wide variety pollutants, mainly, NO2 (oxide of nitrogen) which had rising impact on city air quality (Mage *et al.*, 1996). According to Goyal, (2003) Evaluation air pollution is imperative to be acquainted with the baseline position of a variety of parameters such as nitrogen dioxide (NO2), carbon dioxide (CO2), carbon monoxide (CO), sulphur dioxide (SO2), suspended particulate matters (SPM), and small solid atoms as well as lead from gasoline chemical addition known as particulates. Goyal, (2003) stated that discharge of particulate matter and gaseous from auto exhausts and industries are main cause of increasing discomfort, respiratory illness and cultural patrimony and corrosion of artistic in city areas mainly nitrogen dioxide (NO2), carbon monoxide (CO), sulphur dioxide (SO2), carbon dioxide (CO2), particulate matters and small solid elements. Previous research has confirmed that air pollutants may be associated with hospitalization or asthma prevalence and a lot of these studies focused on publicity based on closeness to road ways (English *et al.,* 1997; Edwards *et al.,* 1994).

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