Poll Res. 40 (3) : 955-960 (2021)

ISSN 0257–8050

WATER QUALITY ANALYSIS OF MAAN STREAM (HIMACHAL PRADESH), INDIA

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(Received 16 April, 2021; Accepted 30 May, 2021)

ABSTRACT

Maan stream is located at 31^{O} 45.708N; 76^{O} 20.532 E in district Hamirpur (Himachal Pradesh), India. It originates from Barsar area of this district and joins the river Beas near Kohla village in Nadaun area. Hareta, Bumblu and Maseh khad are the important brooks joining this stream. This stream is 40 Km long and has catchment area is approximately 183.5 sq. km. It is perennial stream. The stream flows roughly in North-North West (NNW) direction showing a number of hairpin bends. This stream traverses through rocks comprising middle and upper Shivalik region of Himalayas. Physico-chemical parameters of this stream, which is a tributary of river Beas, were studied for water quality analysis, during March 2019 to February 2020. The stream was divided in to six sampling sites for this purpose. Physico-chemical parameters were studied during the summer, winter and monsoon seasons. These parameters were compared with the standard permissible limits prescribed by BIS (2012). These parameters were within the permissible limit except calcium hardness at some of the sites.

KEY WORDS: Hill streams, Water Quality, Seasons, Physico-chemical parameters.

INTRODUCTION

The water is important for all living organisms, i.e. microbes to man. The quality of water is most important for phytoplankton, zooplankton and other faunal diversity of both lentic and lotic ecosystems. The water quality is characterized by various physico-chemical parameters. These parameters are affected by sources of water, pollution, seasonal variations, urbanization and various anthropogenic activities.

Variability in the physico-chemical parameters for different flow periods could be assigned to dilution of river water by direct runoff, human activities and organic load (Hussain *et al.*, 2002). Turbidity, conductivity, pH, chlorides, alkalinity, hardness and BOD of river is pre-monsoon> monsoon> post-monsoon (Mini *et al*., 2003). Studies on physico-chemical and biological parameters have been performed by Rajurkar *et al.* (2003); Kumar *et al.* (2004); Chandra and Gupta (2005); Sharma and Joshi (2005); Sanap *et al*. (2006), Rajashekhar *et al* (2007); Anuradha *et al.* (2012) and Patil (2014). Sharma *et al*. (2017) assessed physico-chemical parameters of lentic water bodies from Mid-Himalayan region (H.P.), India. They found that pH, free CO_2, DO and nitrates were within limits. Due to which water bodies can be used to enhance the fish production through small scale aquaculture practices. The objectives of the present study were (1) To determine the various seasonal physico-chemical parameters of the Maan stream (2) To determine the pollution status of the Maan stream.

MATERIALS AND METHODS

Study Area

Himachal Pradesh is situated in the Western Himalayas having latitude between 30°30' to 33°15' N and longitude 75°30' and 79°00' E. Himachal Pradesh is surrounded by five Indian states namely, Jammu and Kashmir, Uttar Pradesh, Uttarakhand, Punjab and Haryana in the north and north-west, south, south-east, south-west and south,

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respectively. It shares international boundaries with China and Tibet in the northeast. It has an area of 55,673 sq. km and contains twelve districts. Its altitude ranges from 261 -7000 m (Jaret, 2004). The state is rich in water resources having a snow fed perennial rivers, seasonal streams, reservoirs, ponds and natural lakes.

Hamirpur is located in the southwestern part of the Himachal Pradesh and is situated between 75° 47' 55'' to 79° 04'22''east longitude and 30° 22'40'' to 33°12''40'' north latitude. The entire tract of district Hamirpur is hilly and covered by lower Himalayas known as Shivalik range. It is the smallest district of the Himachal Pradesh having a total area of 1118 square Km (2.01 % of the State). The District has the highest population density in the State *i.e.* 369 persons per square Km of the State. Total population of district Hamirpur is 454768 (2011census). This district has the highest literacy rate and highest density of motorable roads per sq. km. The district is bound in the north by river Beas which separates it from the district Kangra. Its elevation ranges from 470-1230 m above the mean sea level. It has many low hills ranges which run North West to South East direction and of them Jakh, Sola singi, Chaumukhi and Chabutra Dhars are prominent. Jakh dhar in continuation of Kalidhar range in the Kangra district. It enters Hamirpur near Nadaun and traverses in the south east direction. The hills are bare, rugged and full of deep ravines in the east; the Bakkar and Seer Khad separate it from Mandi district. In the south it is bounded by Bilaspur district and on the west by Una district. Beas is the major river flowing along the northern boundary of district Hamirpur.

The climate of district Hamirpur is humid subtropical. The annual average temperature is 20°C to 40 °C, minimum and maximum respectively. The average annual rainfall of the district is 1462 mm. The district Hamirpur is drained by both perennial and non-perennial streams. Major streams are Bakaar, Pung, Kunah and Maan stream (Maan khad) which are tributaries of river Beas.

Maan stream has been selected for the present study. Maan stream is a tributary of Beas river. It is a perennial stream. It originates from Barsar area, at above 1048 Meters amsl (above mean sea level) and joins river Beas near Kohla village where the altitude drops to 470 m amsl. Beas river is one of the tributaries of the Indus river system. Pong reservoir a Ramsar site has been created by damming the river Beas by Pong dam in district Kangra, Himachal Pradesh. The stream flows roughly in North-North West (NNW) direction showing a number of hairpin bends. This stream traverses through rocks comprising middle and upper Shivalik. Important brooks of the Maan stream are Haretta, Bumblu and Maseh khad. Total length of this stream is about 40 km & total catchment area is approximately 183.5 sq. km.

Six sites were selected for the present study having following characteristics:

i. Easy accessibility ii. Different habitats
iii. Different substrate compositions iv. The outlets, inlets and particular morphometric features.

From the origin of the stream towards its confluence with river Beas the sites were-

Site-I: Karahe

The site is near the origin of the stream. This site elevation is about 731 m and located at N31°41.552 E076°31.670. This site is near the crematorium and hence a lot of waste materials after the death rituals are floated in this water.

Site - II: Ree

This is the second site, having an elevation of 672 m. and located at N31°35.343 E076°26.087. This site is near village Ree and is was facing anthropogenic activities for performing different rituals near the stream especially during festivals. Here deep pools of water were located.

Site - III: Sandvi

This is the third site having an elevation 645 m. It is located at N31°36.076 E076°25.482.This site was facing relatively less human activities.

Site - IV: Kashmir

This is the fourth site having an elevation 603 m. It is located at N31°37.0763 E076°23.796. This site was being used by the inhabitants of the area, for cremation.

Site - V: Gouna Karore

This is the fifth site having an elevation 545 m. It is located at N31°44.385 E076°21.525. In this site water is flowing with slow speed and it has more flood plain area. This site was facing exploitation due to removal of gravel, sand and stones for construction purpose. Migrated laborers were found temporarily settled near this site.

Site - VI: Manpul

This is the sixth site having elevation 513 m. It is located at N31^{O}45.708 E076^{O}20.532. This site was near the confluence of this stream with Beas river. National highway no. 70 also crosses this stream through a bridge, here. Speed of water is slow here (lentic). This site was facing anthropogenic activities, being near to the town (Nadaun town). Bathing, washing adding waste materials and extraction of sand, gravels and stones were common activities in this site. This site was also being used for cremation. Various physico-chemical characteristics and biological parameters were studied for these six sites.

Methodology

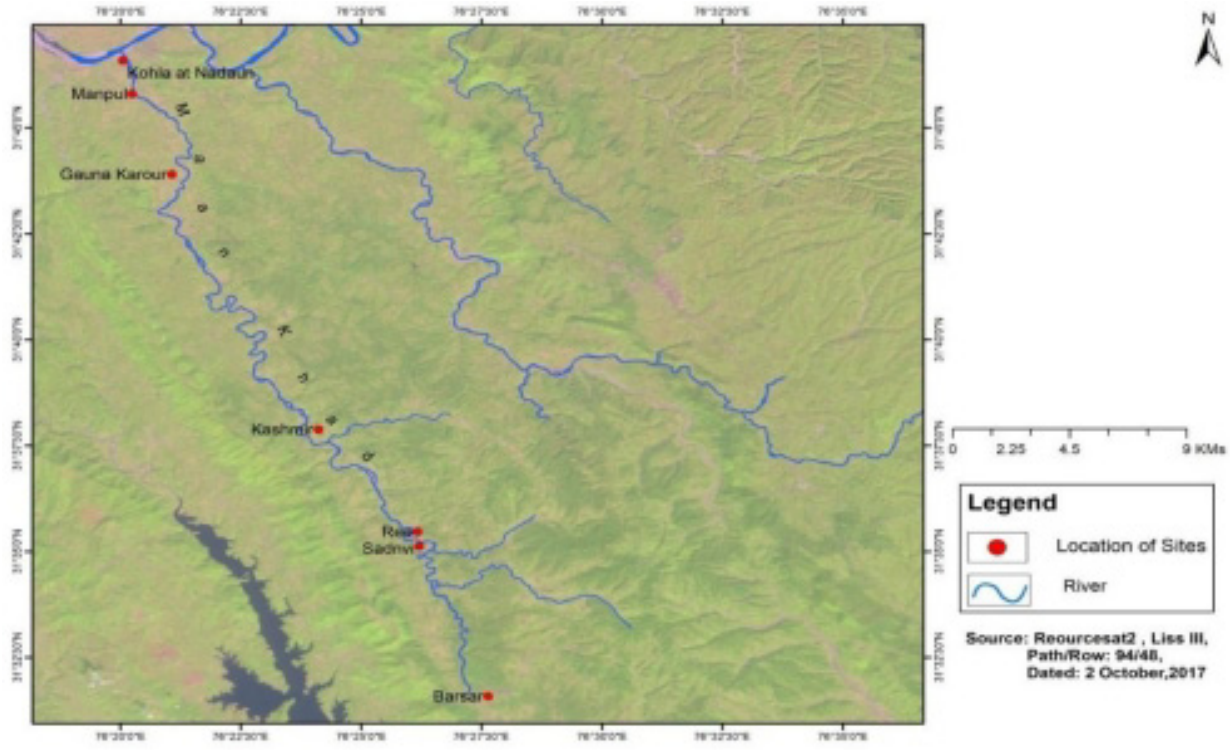
In order to assess the water quality of Maan stream water samples were collected from the six selected sampling sites, on the monthly intervals during March 2019-February 2020. Study period from March-June was included in summer season, July-October was included in Monsoon season and November -February was included in winter season. The water samples were collected at about 15 cm depth from Maan stream, using dip and grab sampling method. Four water samples were collected during each season. Average of all the four readings of samples of a season was taken and used for analysis. The temperature, pH, Conductivity and TDS, was recorded using (Apera Instruments PC60), transparency was recorded using Secchi disc. All the other samples were preserved with concentration HNO_3 (2ml/l) and analyzed. Total hardness, Mg hardness, Ca hardness, Alkalinity, Chloride and Free CO_2 were analyzed by titration method. Phosphate, Nitrate, Silicate and Iron were determined using UV- Spectrophotometer (SHIMADZU-1700).

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were measured by Winkler Azide Method as well as digital method, after appropriate calibration, according to standard calibration procedures. All the data obtained was subjected to statistical analysis.

RESULT AND DISCUSSION

According to Bureau of Indian Standards (BIS, 2012) desirable limits of physico-chemical parameters of drinking water are: pH 6.5-8.5, Total dissolved solids- 500 ppm, Alkalinity 200 mg/l, Calcium hardness- 75 mg/l, Magnesium hardness- 30 mg/l and Nitrate 45 mg/l.

The results for parameters on physico-chemical characteristics of water quality of Maan stream are



Satellite Image of Maan Stream (Source: H.P. Council for Science, Technology and Environment, Shimla

presented in Table 1 and 2. The parameter wise discussion is given as:

Temperature: Water temperature varies with changing climatic conditions. Hutchinson (1957) stated that temperature is important in controlling both the quality and quantity of plankton flora. Water temperature of Maan stream varied from a minimum 15.1 °C to 35.4 °C.

Transparency: The secchi disc transparency ranged between 26 cm to 77 cm. The maximum secchi disc visibility, 77 cm was recorded in the site-3 (Sandvi) during Winter season while minimum 26 cm was recorded in site- 1 Karahe in Monsoon season.

pH: The pH values were found alkaline throughout the study ranging from 8.01 to 8.81. Lowest pH was observed at Ree (site-2) in Summer season and highest at Gouna Karore (site-5) in Winter season. The high pH in this case may be attributed to sewerage discharged by surrounding human population.

Electrical Conductivity (EC): The electrical conductivity of Maan stream has been found to vary from 311.75 µS/cm at Kashmir in Monsoon season to 658.7 µS/cm at Karahe in Winter season.

Total dissolved solids (TDS): Total dissolved solids of Maan stream has been found to be lowest 211.25 mg/l (Summer season) at Maanpul and 463.7 mg/L(Winter season) highest at Karahe. Season wise, TDS was highest in winter season followed by Monsoon and lowest in Summer seasons.

Total hardness: Total hardness of Maan stream was varied from 117.5 mg/l (Ree) in summer season and Highest was 352.5 mg/l (Karahe) in winter season. Highest hardness was observed in winter season followed by Monsoon and lowest in summer season.

Mg Hardness: Mg hardness was observed minimum 5.18 mg/l at Sandvi in Summer season and maximum 31.72 mg/l at Maan pul site in winter season.

Ca Hardness: Ca hardness was varied from 95.0 mg/l lowest (Ree) in summer season and 297.5 mg/l highest at (Karahe) in Winter season. Maximum Ca hardness was observed in winter season, followed by Monsoon and minimum in summer season.

Table 1. Seasonal analysis of physico-chemical parameters of Maan Stream district Hamirpur (H.P.), India

S. No.	Parameter	Site -1			Site-2			Site-3		
		Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter
1	Water Temperature (°C)	26.0±0.14	23.2±0.7	13.4±0.12	28.0±0.19	30.7±0.57	17.8±0.12	30.5±0.17	32±0.42	16.0±0.62
2	Depth of Transparency (Cm)	30±0.56	26±5.13	45±0.51	60±0.36	42±12.38	70±0.74	68±0.85	45±10.80	77±0.53
3	pH	8.21±0.15	8.20±0.06	8.41±0.06	8.01±0.13	8.16±0.17	8.12±0.07	8.42±0.13	8.26±0.14	8.26±0.11
4	Electrical Conductivity (µS/m)	509.2±6.8	603±21.41	658.7±11.57	343.5±6.5	331.2±3.2	356.5±3.7	323.5±2.69	332.75±11.90	329.7±3.89
5	Total Dissolved Solids (ppm)	386±3.9	427.5±13.5	463.7±7.10	241.5±4.97	2.47±5.19	249.5±3.35	229.7±4.14	246±2.1	346.7±20.83
6	Total Hardness (mg/l)	272.5±8.29	351.2±11.38	352.5±8.29	117.5±14.79	202.5±17.85	242.5±14.79	167.5±21.6	185±55	225±7.0
7	Mg Hardness (mg/l)	22.87±2.65	19.20±4.32	13.42±2.52	5.49±5.23	10.98±6.45	14.64±5.23	5.18±3.52	17.93±2.85	28.97±1.82
8	Ca Hardness (mg/l)	178.75±5.4	272.5±21.6	297.5±10.8	95±18.02	157.5±10.89	182.5±8.29	146.25±6.49	111.5±7.5	106.25±5.92
9	Alkalinity (mg/l)	72.5±8.29	66.25±4.15	135±11.18	160±7.07	137.5±14.79	202.5±17.8	205±11.18	141.25±21.14	207.5±8.29
10	Chloride (mg/l)	39.5±4.97	34.7±0.83	30.25±1.29	23±1.22	19.5±1.11	18.7±1.92	17.2±0.83	14.32±0.33	13.4±0.29
11	Free CO_2 (mg/l)	2±0.27	1±0.35	2.4±0.42	2.8±0.39	2.6±0.44	3.0±0.41	4.6±0.25	2.9±0.19	6.6±0.28
12	Phosphate (mg/l)	1.33±0.02	3.6±0.12	2.34±0.01	0.65±0.11	0.85±0.04	0.72±0.19	0.70±0.01	1.3±0.15	0.90±0.22
13	Nitrate (mg/l)	1.3±0.08	2.3±0.04	2.2±0.10	1.7±0.57	4.0±0.65	2.1±0.58	0.84±0.04	2.5±0.18	1.0±0.07
14	Silicate (mg/l)	2.2±0.27	1.7±0.08	2.4±0.21	1.9±0.07	1.8±0.22	2.6±0.33	2.2±0.15	1.3±0.30	2.4±0.11
15	Iron (mg/l)	0.07±0.01	0.1±0.11	0.03±0.00	0.05±0.02	0.06±0.02	0.05±0.01	0.04±0.005	1.0±0.07	0.05±0.01
16	Dissolved Oxygen (mg/l)	5.2±0.11	9.2±0.08	9.4±0.38	6.06±0.15	6.87±0.16	7.7±0.70	4.6±0.16	5.6±0.16	6.6±0.15
17	Biological Oxygen Demand (mg/l)	0.9±0.27	1.55±0.21	0.7±0.25	2.5±0.27	2.7±0.11	1.4±0.25	3.4±0.86	5.1±0.18	2.7±0.16

Table 2. Seasonal analysis of physico-chemical parameters of Maan Stream district Hamirpur (H.P.), India

S. No.	Parameter	Site-4			Site-5			Site-6		
		Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter
1	Water Temperature (°C)	35.4±0.11	31.1±1.28	16.4±0.38	34.9±0.37	33±0.14	15.3±0.34	34.3±0.25	30.3±0.33	15.1±0.35
2	Depth of Transparency (Cm)	60±0.25	48±0.56	70.5±0.83	70±8.32	50±12.4	74±8.24	65±0.45	55±0.53	71±0.86
3	pH	850±0.13	8.38±0.02	8.42±0.01	8.71±0.03	8.34±0.007	8.81±0.008	8.10±0.14	8.70±0.08	8.41±0.1
4	Electrical Conductivity (µS/m)	317±4.9	313±3.3	345.7±0.43	327±2.12	312.5±12.56	339.5±12.45	389.75±2.94	311.75±11.16	377.25±3.68
5	Total Dissolved Solids (ppm)	219.2±5.93	223.5±3.20	247±0.70	230.75±6.60	242±6.22	272.25±12.86	211.25±1.78	255.5±10.01	269.5±4.09
6	Total Hardness (mg/l)	175±11.1	185±11.1	282.5±14.7	160±9.3	185±11.18	225±5.0	192.5±10.89	230±7.07	270±7.07
7	Mg Hardness (mg/l)	9.15±2.52	11.28±5.20	29.28±2.53	10.98±4.23	15.25±3.52	17.69±3.90	14.94±2.30	23.79±3.54	31.72±5.01
8	Ca Hardness (mg/l)	137.5±14.75	138.75±7.35	162.5±4.33	115±11.18	122.5±10.89	152.5±11.85	131.25±17.44	132.5±8.29	140±0.35
9	Alkalinity (mg/l)	85±11.1	65±11.1	90±7.07	55±11.18	52.5±8.29	55±3.5	315±16.58	266.25±8.29	321.25±24.59
10	Chloride (mg/l)	17.0±0.61	14±0.25	12.2±0.25	18.75±0.32	17.5±0.5	15.5±1.11	24.25±1.65	20.75±0.82	18±1.58
11	Free CO_2 (mg/l)	6.5±0.21	4.1±0.12	6.8±0.23	2.1±0.12	1.8±0.26	3.5±0.15	2.52±0.65	2.27±0.29	3.9±0.65
12	Phosphate (mg/l)	0.40±0.01	0.81±0.06	0.50±0.07	0.46±0.05	1.32±0.58	0.72±0.02	0.10±0.01	0.49±0.03	0.29±0.13
13	Nitrate (mg/l)	1.5±0.29	2.9±0.36	1.7±0.56	1.4±0.26	2.12±0.08	1.9±0.05	1.8±0.07	2.6±0.05	1.5±0.35
14	Silicate (mg/l)	2.2±0.12	1.4±0.12	2.3±0.43	1.9±0.15	1.4±0.12	2.1±0.07	1.4±0.11	1.2±0.15	1.7±0.16
15	Iron (mg/l)	0.04±0.00	0.04±0.00	0.04±0.01	0.8±0.28	0.30±0.12	0.05±0.007	0.17±0.08	0.17±0.08	0.07±0.04
16	Dissolved Oxygen (mg/l)	5.5±0.15	5.6±0.18	6.4±0.23	7±0.27	7.5±0.11	8.4±0.02	5.8±0.43	6.0±0.08	6.4±0.44
17	Biological Oxygen Demand (mg/l)	3.2±0.19	3.6±0.38	2.0±0.07	2.2±0.27	2.3±0.22	1.3±0.12	3.2±0.19	5.9±0.38	3.0±0.07

Alkalinity: The change of alkalinity depends on carbonates and bicarbonates, which in term depend upon release of CO_2. The amount of total alkalinity in Maan stream ranges between 52.5 mg/l (Gouna karore) to 321.25 mg/l (Maanpul). The minimum value of Alkalinity was observed in Monsoon season and Maximum value of Alkalinity was observed in winter season.

Chloride: The Lowest amount of chloride recorded in the Maan stream was 12.2 mg/l at Kashmir and highest 39.5 mg/l at Karahe. Minimum Chloride was recorded during Winter season and the maximum amount was recorded during summer season.

Free CO_2: Free CO_2 ranges in between 1.0 mg/l to 6.8 mg/l. lowest free CO_2 was observed at Karahe in Monsoon season and highest at Kashmir in Winter season.

Phosphate: In Maan stream the amount of phosphate recorded ranges between 0.10 mg/l (Maanpul) to 3.6 mg/L (Karahe). Excess amount of phosphate may cause eutrophication leading to extensive algal growth called algal blooms. The maximum value of phosphate during Monsoon season may be due to surface runoff during rainy season. The lower value of phosphate in summer month may be due to more uptake of phosphate for abundant growth of macro-phytes.

Nitrate: Nitrates are contributed to freshwater through discharge of agricultural wastes which runoff from agriculture field. In Maan stream the amount of nitrate was recorded ranges between 1.0 mg/l (Sandvi) to 4.0 mg/l (Ree).The minimum amount of nitrate in water of Maan stream was recorded during summer season, whereas maximum amount of nitrate was recorded during Monsoon.

Silicate: The amount of silicate recorded in Maan stream ranges between 1.2 mg/l (Maanpul) to 2.6 mg/l (Ree). The higher amount of Silicate was observed in winter season and minimum amount of Silicate was observed in Monsoon season.

Iron: Amount of Iron was low in the water of this stream. It was ranging between 0.03 mg/l (Karahe) in winter season to 1.0 mg/l (Sandvi) at Monsoon season.

Dissolved Oxygen (DO): The amount of dissolved O_2 recorded in water of Maan stream ranges between 4.6 mg/l (Sandvi) in Summer

Season to 9.4 mg/l (Karahe) in winter season. The amount of O_2 was minimum in summer season and maximum in winter season. The high temperature and addition of sewage and other wastes might be responsible for low value of DO.

Biochemical Oxygen Demand (BOD): BOD refers the oxygen used by the microorganism in the aerobic oxidation of organic matter. Therefore with the increase in the amount of organic matter in the water the BOD increases. The BOD value of Maan stream ranges between 0.7 mg/l (Karahe) in winter season to 5.9 mg/l (Maanpul) in Monsoon season. The higher value of BOD during Monsoon was due to input of organic wastes and enhanced bacterial activity.

CONCLUSION

According to the present study we can conclude that most of the physico-chemical parameters of Maan stream were within permissible limit as per Indian standard for drinking water except Ca hardness of some sites were more than permissible limits. Hence water of this stream can be used for drinking purpose after treatment to low down the Ca hardness. Otherwise more Ca hardness may cause renal calculi in near future. The present study may also help to provide baseline data to stakeholders and government officials to plan conservation strategies and monitor this stream. All the selected sites were having good physico-chemical properties *i. e.* normal to the suggested values as per APHA 2005. Water of this stream was free from pollution and may be used for aquaculture practices as a small scale fisheries of fishes and or prawns.

ACKNOWLEDGEMENT

Authors are thankful to the Principal, NSCBM Govt. College Hamirpur who allowed us to perform the water analysis experiments in its Zoology lab. Authors are also thankful to Mr. Sunil Pathak and Ms.Babita Suman who helped in the sample collection and on the spot measurement of some physical parameters.

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