

Water Quality Assessment of River Beas during Winter Season in Himachal Pradesh, India

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ABSTRACT

Present investigation was carried out in 256 km stretch of river Beas in Himachal Pradesh for analysis of important physical, chemical and biological water quality parameters during winter season. Parameters such as temperature, pH, conductivity, turbidity, alkalinity, total dissolved solids (TDS), total hardness, calcium, magnesium, potassium, sodium, cadmium, copper, iron, lead, chloride, fluoride, nitrate, biological oxygen demand (BOD), chemical oxygen demand (COD), *Colliform* and *Escherichia coli* were analyzed from six sampling stations i.e. Beaskund, Shamshi, Pandohdam, Dharampur, Nadaun and Pongdam in the study area. The analysis of data reveals that turbidity, cadmium and lead, were found to be higher than the acceptable limit prescribed by Bureau of Indian standards (BIS), 2012 for drinking water in India. *Colliform* and *E.coli* were present in all the sampling stations of river Beas except at SS-1 and SS-2. All the other physicochemical parameters excepting pH at SS-5 (8.98 ± 0.057) were within the limit prescribed by World Health Organization (WHO), 2011 and BIS, 2012 for drinking water in India.

Key words: River Beas, Water Quality, Physicochemical, Biological parameters.

INTRODUCTION

The rivers and lakes play an important role in lives of human beings. The rivers provide irrigation, potable water, cheap transportation, hydroelectricity and livelihood to large population on the earth^{1&2}. The Indian river system is classified in to four major categories i.e. The Himalayan, the rivers traversing the Deccan Plateau, the Coastal and those in the inland drainage basin. Indus river of Himalayan system consist of the Chenab, the Jhelum, the Ravi, the Satluj and the Beas³. River Beas, an important contributory of the Indus system, is the only tributary of system confined to India. The river Beas is a perennial river fed by snow, rainfall and is covered with extensive cover of vegetation in Himachal Pradesh. River Beas originates from Beaskund, in Pirpanjal range near Rohtang pass at 13326 ft above mean sea level. Total length of river Beas is 470 km, out of which it flows 256 km in Himachal Pradesh.

The Parvati, Hurla, Sainj, Tirthan, Uhl, Suketi, Looni, Son, Bakkar, Binwa, Neugal, Mankhad, Baner, Banganga and Chakki river are the major tributaries of river Beas in Himachal Pradesh. The important settlements on the bank of river Beas in Himachal Pradesh are Manali, Kulu, Bhuntar, Pandoh, Mandi, Ladbharol, Dharampur, Jaisinghpur, Sujampur Tira, Nadaun and Dehra Gopipur. The river water quality is highly variable by nature due to environmental conditions such as basin lithology, vegetation and climate^{4&5}. There are three major natural sources of dissolved and soluble matter carried by rivers, the atmospheric inputs of material, the degradation of terrestrial organic matter and weathering of surface rocks. With continuous growth of population, rapid developments in agriculture, mining, urbanization, industrialization, hydro-electrical generation activities and motor vehicle pollution, the river water contamination with hazardous waste is becoming common phenomena^{6&7}. The rate of discharge of

pollutants in to the water is far higher than rate of purification. As water quality and human health are closely related and it is in this context, that the water quality assessment is critical for pollution control and protection of surface and ground water^{9,9&10}. The drinking water requirement of the population of Kulu, Mandi, Hamirpur and Kangra districts of Himachal Pradesh is met by uplifting water from river Beas. Besides this, Beas river water is also used for irrigation and hydroelectricity generation. As no systematic study has been undertaken to assess the water quality of river Beas, hence the present investigation was undertaken.

MATERIALS AND METHODS

In order to assess the water quality of river Beas, six sampling stations i.e. 1. Beaskund (SS-1), 2. Shamshi (SS-2), sampling station three 3. Pandoh Dam (SS-3), 4. Dharampur (SS-4), 5. Nadaun (SS-5) and 6. Pongdam (SS-6), were selected on the basis of identified pollution problems and upon the location of points of sources of waste water discharge in the selected stretch of river Beas. Using dip and grab sampling method the water samples were collected at about 15cm depth from river Beas. Three water samples were collected during winter season, one every fifteen days in the month of November and December in the year 2014. The temperature was recorded using mercury thermometer, pH was recorded using digital pH meter (Environmental & Scientific Instruments 111E), turbidity was recorded using digital turbidity meter (Environmental & Scientific Instruments 331E) and conductivity was recorded using digital conductivity meter (Environmental & Scientific Instruments 611E) respectably. All the samples were preserved with conc. HNO₃ (3ml/L) and conc. HCl (0.5ml/200ml) solution for analysis of remaining physicochemical and biological parameters at Environtech Laboratory Mohali, Punjab, India, using standard methods (APHA 2012)¹¹ and other methods (BIS, 1987)¹². Sodium and Potassium were determined using Microprocessor Flame Photometer (Environmental & Scientific Instruments 1382). Iron was determined using Spectrophotometer (Environmental & Scientific Instruments 2373). Cadmium, Copper and Lead were determined using Flame Atomic Absorption Spectrometer (LABINDIA

AA7000). All the instruments were calibrated according to standard calibration procedures. All the data obtained was subjected to statistical analysis mean and standard deviation.

RESULTS

The results of various physicochemical and biological parameters recorded during present study with mean value and standard deviation values at all the six sampling stations are presented in Table 1-6 and comparative analysis of all the six sampling stations is presented in Table 7.

DISCUSSION

Temperature

Temperature of river water effects chemical and biological reactions, conductivity, pH, and soluble gases. The temperature of river Beas varied widely in the study area with SS-1 recording lowest of -2^o C and SS-5 recording highest of 17.5^o C with a mean value of 9.42±6.52^oC.

pH

The pH is measure of acidity or alkalinity of a solution. The mean value of pH of water in study area of river Beas was 7.97±0.55 which was within the acceptable limit of 6.5-8.5 prescribed by BIS, 2012¹³.

Conductivity

The conductivity is numerical expression of water's ability to conduct electric current and depends on the concentration of ions in solution. The mean value of conductivity of water of river Beas in study area was 217.83±137.56 µS/cm.

Turbidity

The turbidity is the measure of suspended sediment such as silt, clay, organic matter, and microscopic organisms in water sample. The mean value of Turbidity of water in study area of river Beas was 1.27±0.97 NTU, which was slightly higher than acceptable limit of one NTU, but was within the permissible limit of 5 NTU prescribed by BIS, 2012. The higher value of 3 NTU of turbidity at SS-4 was due to confluence of high silt content of rivers Looni and Son with river Beas.

Alkalinity

The alkalinity is capacity to neutralize acid and is usually due to the presence of bicarbonates, carbonates and hydroxide. The mean value of alkalinity of water of river Beas in study area was 57.67 ± 24.54 mg/L, which was within the acceptable limit of 500 mg/L prescribed by BIS, 2012.

Total Dissolved Solids (TDS)

The solids are present in water in suspended or dissolved state and the mean value of TDS of river Beas was 144.67 ± 91.43 mg/L, which was within the acceptable limit of 500 mg/L prescribed by BIS, 2012.

Total Hardness

The total hardness is a measure of dissolved polyvalent metallic ions, and is traditional measure of capacity of water to react with soap and produce lather. The mean value of total hardness of water in study area of river Beas was 71 ± 21.62 mg/L, which was within the acceptable limit of 200 mg/L prescribed by BIS, 2012.

Calcium

Calcium causes both carbonate and non carbonate hardness of water. The mean value of calcium in study area of river Beas was 19.17 ± 5.58 mg/L, which was within the acceptable limit of 75

Table 1: Analysis of various parameters during Post Monsoon Season (Winter) at sampling station Beas Kund (SS-1)

Sr. No.	Parameter	Date of collection			Mean Value	S.D.
		11/11/2014	26/11/2014	11/12/2014		
1	Temperature	-1.5	-2	-2.5	-2	± 0.408
2	pH	7.37	7.39	7.35	7.37	± 0.016
3	Conductivity	79	78	77	78	± 0.816
4	Turbidity	0.3	0.5	0.3	0.36667	± 0.094
5	Alkalinity	20	19	21	20	± 0.816
6	TDS ⁺	50	50	56	52	± 2.828
7	Total Hardness	38	37	39	38	± 0.816
8	Calcium	10	9	11	10	± 0.816
9	Magnesium	2.9	2.9	3.2	3	± 0.141
10	Potassium	0.7	0.7	1	0.8	± 0.141
11	Sodium	0.9	0.9	1.2	1	± 0.141
12	Cadmium	0.006	0.007	0.008	0.007	± 0.001
13	Copper	0.0002	0.0003	0.0004	0.0003	± 0.000
14	Iron	0.02	0.02	0.05	0.03	± 0.014
15	Lead	0.0392	0.0395	0.0398	0.0395	± 0.000
16	Chloride	5.5	5.7	5.9	5.7	± 0.163
17	Fluoride	0.3	0.32	0.4	0.34	± 0.043
18	Nitrate	0.03	0.04	0.05	0.04	± 0.008
19	BOD at 27°C for 3 days**	0	0	0	0	± 0.000
20	COD***	0	0	0	0	± 0.000
21	Colliform	P	A	A		
22	Escherichia coli	P	A	A		

mg/L prescribed by BIS, 2012. This concentration of calcium in river water may be due to occurrence of highly soluble halides, gypsum and easily weathered surface rocks in the study area¹⁴. The controlled amount of calcium is good for health and is an important factor influencing metabolism and growth, and WHO, 2011 has not proposed any guideline value of calcium¹⁵.

Magnesium

Magnesium contributes both carbonate and non carbonate hardness to water. The mean

value of magnesium in study area of river Beas was 5.47 ± 2.12 mg/L, which was within the acceptable limit of 30 mg/L prescribed by BIS, 2012.

Potassium

Potassium occurs widely in environment and natural water sources and is an essential element in humans. The mean value of potassium in study area of river Beas was 2.05 ± 0.61 mg/L. The BIS, 2012 and WHO, 2011 has not prescribed any guideline value of the potassium, however

Table 2: Analysis of various parameters during Post Monsoon Season (Winter) at sampling station Shamshi (SS-2)

Sr. No.	Parameter	Date of collection			Mean Value	S.D.
		11/11/2014	26/11/2014	11/12/2014		
1	Temperature	6.2	6	5.8	6	± 0.163
2	pH	7.44	7.42	7.37	7.41	± 0.029
3	Conductivity	111	110	109	110	± 0.816
4	Turbidity	1.2	3	2.2	2.13333	± 0.736
5	Alkalinity	34	38	39	37	± 2.160
6	TDS*	71	75	70	72	± 2.160
7	Total Hardness	54	54	57	55	± 1.414
8	Calcium	13.5	14.5	17	15	± 1.472
9	Magnesium	3.5	3.5	5	4	± 0.707
10	Potassium	2.1	2	2.2	2.1	± 0.082
11	Sodium	3.1	3	3.2	3.1	± 0.082
12	Cadmium	0.005	0.002	0.004	0.00367	± 0.001
13	Copper	0.0022	0.0023	0.003	0.0025	± 0.010
14	Iron	0.15	0.16	0.17	0.16	± 0.008
15	Lead	0.0309	0.0303	0.0309	0.0307	± 0.000
16	Chloride	6.7	6.8	7.2	6.9	± 0.216
17	Fluoride	0.58	0.57	0.56	0.57	± 0.008
18	Nitrate	1.3	1.2	1.1	1.2	± 0.082
19	BOD at 27°C for 3 days**	0.7	0.6	0.5	0.6	± 0.082
20	COD***	4.9	4.7	4.5	4.7	± 0.163
21	Colliform	P	P	A		
22	Escherichia coli	P	P	A		

high concentration of potassium affects individuals suffering from heart and kidney diseases.

Sodium

Sodium is found virtually in all foods and drinking water and the mean value of sodium in water of study area of river Beas was 19.88 ± 22.35 mg/L. The highest mean value of 61 mg/L was found at SS-4 and may have been due to confluence of river Beas with Looni river, draining the Gumma and Darang area of district Mandi having salt deposits¹⁶.

Cadmium

The pollution of water with cadmium is caused by contamination from mining, fertilizers

and tobacco products. The mean value of cadmium in water of study area of river Beas was 0.004 mg/L which was higher than acceptable limit of 0.003 mg/L prescribed by BIS, 2012. The higher value of cadmium may be due to extensive mining activities and extensive use of fertilizers in the study area¹⁷.

Copper

The copper is used in making pipes, valves, alloys coating and is both essential nutrient and drinking water contaminant. The mean value of copper in water of river Beas was 0.0017 mg/L, which was within the acceptable limit of 0.5 mg/L and 2 mg/L prescribed by BIS, 2012 and WHO, 2011 respectively.

Table 3: Analysis of various parameters during Post Monsoon Season (Winter) at sampling station Pandoh Dam (SS-3)

Sr. No.	Parameter	Date of collection			Mean Value	S.D.
		12/11/2014	27/11/2014	12/12/2014		
1	Temperature	8.5	8	7.5	8	± 0.408
2	pH	7.77	7.75	7.7	7.74	± 0.029
3	Conductivity	135	134	130	133	± 2.160
4	Turbidity	0.7	0.5	0.09	0.43	± 0.254
5	Alkalinity	46	47	48	47	± 0.816
6	TDS [†]	87	87	90	88	± 1.414
7	Total Hardness	62	62	65	63	± 1.414
8	Calcium	15	18	21	18	± 2.449
9	Magnesium	4	4	4.3	4.1	± 0.141
10	Potassium	2.3	2.4	2.5	2.4	± 0.082
11	Sodium	6.4	6.5	6.6	6.5	± 0.082
12	Cadmium	0.002	0.003	0.004	0.003	± 0.001
13	Copper	0.0027	0.0029	0.0031	0.0029	± 0.000
14	Iron	0.24	0.23	0.22	0.23	± 0.008
15	Lead	0.0265	0.0266	0.0267	0.0266	± 0.000
16	Chloride	11.7	12.3	12	12	± 0.245
17	Fluoride	0.57	0.56	0.55	0.56	± 0.008
18	Nitrate	1.4	1.3	1.2	1.3	± 0.082
19	BOD at 27°C for 3 days**	1.4	1.1	0.8	1.1	± 0.245
20	COD***	1.5	1.3	1.1	1.3	± 0.163
21	Colliform	P	P	P		
22	Escherichia coli	P	P	P		

Iron

Iron is one of most abundant metal in earths crust, found in natural water and is essential element in human nutrition. The mean value of iron in the water of river Beas in study area was 0.30 ± 0.18 mg/L, which was at par with acceptable limit of 0.3 mg/L prescribed by BIS, 2012. However WHO, 2011 has not proposed any guideline value for drinking water as daily requirement of human is 10-50 mg/day.

Lead

The lead is used as anti knocking and lubricating agent in vehicle fuels, paints, acid batteries, solder and alloys. The mean value of lead in water of river Beas was 0.03 ± 0.01 mg/L, which was higher than the acceptable limit of 0.01mg/L

prescribed by BIS, 2012 and WHO, 2011. The contamination of river water may have been due to emissions from vehicular traffic along the river Beas and weathering of galena rocks in the study area¹⁸.

Chloride

The mean value of chloride in water of study area of river Beas was 34.10 ± 35.24 mg/L, which was within the acceptable limit of 250 mg/L prescribed by BIS, 2012. The mineral deposits, sewage water, human excreta, domestic and industrial waste are the various sources which contribute chloride in water. The highest mean value of 96 mg/L was found at SS-4 and may have been due to confluence of river Beas with Looni river, draining the Gumma and Darang area of district Mandi having salt deposits.

Table 4: Analysis of various parameters during Post Monsoon Season (Winter) at sampling station Dharampur (SS-4)

Sr. No.	Parameter	Date of collection			Mean Value	S.D.
		12/11/2014	27/11/2014	12/12/2014		
1	Temperature	11.2	11	10.8	11	± 0.163
2	pH	8.18	8.17	8.16	8.17	± 0.008
3	Conductivity	455	453	448	452	± 2.944
4	Turbidity	1	6	2	3	± 2.160
5	Alkalinity	84	83	85	84	± 0.816
6	TDS [*]	296	301	303	300	± 2.944
7	Total Hardness	94	93	95	94	± 0.816
8	Calcium	22	23	24	23	± 0.816
9	Magnesium	9	8.9	8.8	8.9	± 0.082
10	Potassium	2.5	2.5	2.8	2.6	± 0.141
11	Sodium	60	60	63	61	± 1.414
12	Cadmium	0.005	0.006	0.002	0.00433	± 0.002
13	Copper	0.0016	0.0017	0.0021	0.0018	± 0.000
14	Iron	0.1	0.2	0.3	0.2	± 0.082
15	Lead	0.0251	0.025	0.0255	0.0252	± 0.000
16	Chloride	96	94	98	96	± 1.633
17	Fluoride	0.55	0.57	0.59	0.57	± 0.016
18	Nitrate	1.2	1.6	1.7	1.5	± 0.216
19	BOD at 27°C for 3 days**	0.7	0.5	0.3	0.5	± 0.163
20	COD***	11	9.5	8	9.5	± 1.225
21	Colliform	P	P	P		
22	Escherichia coli	P	P	P		

Chloride in drinking water are not detrimental normally to health and WHO, 2011 has not proposed any guideline value for drinking water.

Fluoride

The mean value of fluoride in water of study area of river Beas was 0.54 ± 0.11 mg/L, which was within the acceptable limit of 1 mg/L and 5 mg/L prescribed by BIS, 2012 and WHO, 2011 respectively. The fluorides are essential to drinking water for prevention of dental caries, but higher concentration of fluoride may cause dental fluorosis.

Nitrate

The mean value of nitrate in water of river Beas in the study area was 0.87 ± 0.51 mg/L, which was within the acceptable limit of 45 mg/L prescribed by BIS, 2012 and WHO, 2011 respectively. Basic source of nitrates is nitrogen which is constituent of proteins, chlorophyll and many other biological compounds. Higher concentration of nitrate in drinking water is a health hazard and has carcinogenic impact on the digestive system¹⁴.

Biological Oxygen Demand (BOD)

The BOD is measure of oxygen in water that is required by aerobic organisms and is an indicator

Table 5: Analysis of various parameters during Post Monsoon Season (Winter) at sampling station Nadaun (SS-5)

Sr. No.	Parameter	Date of collection			Mean Value	S.D.
		13/11/2014	28/11/2014	13/12/2014		
1	Temperature	17.9	17.6	17	17.5	± 0.374
2	pH	9.02	9.02	8.9	8.98	± 0.057
3	Conductivity	353	355	357	355	± 1.633
4	Turbidity	2	0.3	1	1.1	± 0.698
5	Alkalinity	81	84	87	84	± 2.449
6	TDS*	234	236	238	236	± 1.633
7	Total Hardness	99	100	101	100	± 0.816
8	Calcium	24	28	29	27	± 2.160
9	Magnesium	7.7	7.5	7.9	7.7	± 0.163
10	Potassium	2.3	2.3	2.9	2.5	± 0.283
11	Sodium	36	39	42	39	± 2.449
12	Cadmium	0.005	0.006	0.007	0.006	± 0.001
13	Copper	0.0018	0.0019	0.0020	0.0019	± 0.000
14	Iron	0.6	0.7	0.8	0.7	± 0.082
15	Lead	0.0354	0.0355	0.0356	0.0355	± 0.000
16	Chloride	68	69	70	69	± 0.816
17	Fluoride	0.48	0.48	0.49	0.48333	± 0.005
18	Nitrate	0.3	0.3	0.9	0.5	± 0.283
19	BOD at 27°C for 3 days**	2.2	2	1.8	2	± 0.163
20	COD***	4.4	3.8	3.2	3.8	± 0.490
21	Colliform	P	P	P		
22	Escherichia coli	P	P	P		

of organic pollution. The mean value of BOD in water of river Beas in the study area was 0.83 ± 0.62 mg/L. The BIS, 2012 and WHO, 2011 has not proposed any guideline values of BOD for drinking water.

Chemical Oxygen Demand (COD)

The COD is amount of chemical oxidant required for oxidation of organic matter that is present in water. The mean value of COD in water of river Beas in the study area was 3.53 ± 3.09 mg/L. The BIS, 2012 and WHO, 2011 has not proposed any guideline values of COD for drinking water.

Colliform and Escherichia coli

The colliforms are useful indicators of the possible presence of enteric pathogenic bacteria. The colliform and *E. coli* were found in all sampling stations except SS-1 and SS-2. The BIS, 2012 and WHO, 2011 has prescribed nil presence of colliform and *E. coli* in drinking water. The present investigation reveals that Colliform and *E. coli* were present in the water at all the sampling stations except at SS-1 and SS-2. Barring lead, cadmium and turbidity all other physicochemical and biological water quality parameters were within the acceptable limit of BIS, 2012.

Table 6: Analysis of various parameters during Post Monsoon Season (Winter) at sampling station Pong Dam (SS-6)

Sr. No.	Parameter	Date of collection			Mean Value	S.D.
		13/11/2014	28/11/2014	13/12/2014		
1	Temperature	16.3	16	15.7	16	± 0.245
2	pH	8.15	8.17	8.1	8.14	± 0.029
3	Conductivity	178	178	181	179	± 1.414
4	Turbidity	0.3	0.5	0.9	0.56667	± 0.249
5	Alkalinity	71	74	77	74	± 2.449
6	TDS ⁺	118	121	121	120	± 1.414
7	Total Hardness	75	76	77	76	± 0.816
8	Calcium	21	22	23	22	± 0.816
9	Magnesium	5	5	5.3	5.1	± 0.141
10	Potassium	1.8	1.8	2.1	1.9	± 0.141
11	Sodium	8.5	8.9	8.7	8.7	± 0.163
12	Cadmium	0	0	0	0	± 0.000
13	Copper	0.0007	0.0009	0.0011	0.0009	± 0.000
14	Iron	0.3	0.2	0.1	0.2	± 0.082
15	Lead	0.0257	0.0257	0.0263	0.0259	± 0.000
16	Chloride	14.5	14.5	16	15	± 0.707
17	Fluoride	0.68	0.68	0.71	0.69	± 0.014
18	Nitrate	0.6	0.6	0.9	0.7	± 0.141
19	BOD at 27°C for 3 days**	0.9	0.8	0.7	0.8	± 0.082
20	COD***	2.2	1.9	1.6	1.9	± 0.245
21	Colliform	P	P	P		
22	Escherichia coli	P	P	P		

Table 7: Analysis of various parameters during Post Monsoon Season (Winter) at all the six sampling stations.

Sr. No.	Parameter	Unit	Sampling Stations*						Mean Value	S.D.
			SS-1	SS-2	SS-3	SS-4	SS-5	SS-6		
1	Temperature	°C	-2	6	8	11	17.5	16	9.42	± 6.52
2	pH		7.37	7.41	7.74	8.17	8.98	8.14	7.97	± 0.55
3	Conductivity	µS/cm	78	110	133	452	355	179	217.83	± 137.56
4	Turbidity	NTU	0.4	2.1	0.4	3	1.1	0.6	1.27	± 0.97
5	Alkalinity	mg/L	20	37	47	84	84	74	57.67	± 24.54
6	TDS ⁺	mg/L	52	72	88	300	236	120	144.67	± 91.43
7	Total Hardness	mg/L	38	55	63	94	100	76	71.00	± 21.62
8	Calcium	mg/L	10	15	18	23	27	22	19.17	± 5.58
9	Magnesium	mg/L	3	4	4.1	8.9	7.7	5.1	5.47	± 2.12
10	Potassium	mg/L	0.8	2.1	2.4	2.6	2.5	1.9	2.05	± 0.61
11	Sodium	mg/L	1	3.1	6.5	61	39	8.7	19.88	± 22.35
12	Cadmium	mg/L	0.007	0.004	0.003	0.004	0.006	0	0.004	± 0.00
13	Copper	mg/L	0.0003	0.0025	0.0029	0.0018	0.0019	0.0009	0.0017	± 0.00
14	Iron	mg/L	0.3	0.16	0.23	0.2	0.7	0.2	0.30	± 0.18
15	Lead	mg/L	0.0395	0.0307	0.0266	0.0252	0.0355	0.0259	0.03	± 0.01
16	Chloride	mg/L	5.7	6.9	12	96	69	15	34.10	± 35.24
17	Fluoride	mg/L	0.34	0.57	0.56	0.57	0.49	0.69	0.54	± 0.11
18	Nitrate	mg/L	0.04	1.2	1.3	1.5	0.5	0.7	0.87	± 0.51
19	BOD at 27°C for 3 days**	mg/L	0	0.6	1.1	0.5	2	0.8	0.83	± 0.62
20	COD***	mg/L	0	4.7	1.3	9.5	3.8	1.9	3.53	± 3.09
21	Colliform	P/A'	A	A	P	P	P	P		
22	Escherichia coli	P/A'	A	A	P	P	P	P		

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