Physico-Chemical Parameter Variations of Surface Water in Lower Gadilam River, Cuddalore District, Tamil Nadu, India

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Abstract- *The study is to determine the physico-chemical variations of surface water in fourteen stations along the Gadilam River, Cuddalore district of Tamil Nadu, India. Physico - chemical variable in water samples collected along Gadilam River during summer and winter is analyzed for, pH, Electrical conductivity (Ec), Total hardness (TH), Total dissolved solids (TDS) and major elements like Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate with addition of nutrients like Nitrate and Phosphates. The noted increase of electrical conductivity is found in summer, whereas other parameters are more during winter. The study infers that the effluent flow, sewage drainage, catchment runoff and the tides are having great influence on the changes in physico-chemical parameters and fluctuation of macronutrient. The degradation of our river ecosystem and water quality of various rivers all over the country is evaluated to understand the present status of Gadilam River.*

Keywords- Gadilam River, Physico – chemical parameters, Water, Cuddalore.

I. INTRODUCTION

Rivers are the major resources for dependent living beings but due to anthropological activities, river waters are becoming un-usable due to the changes in physico-chemical nature brought about by various kinds of pollutants. On the other hand, due to the reduced rainfall as a consequence of climate change, these water resources are being depleted and increase the alarming rate of pollution. Recent reports indicate that India is expected to face critical levels of water stress by 2025 and there will be serious water shortages (UN Climate Report, 2014). Water is necessary for metabolism and catabolism activity and the importance of water cannot be over emphasized. It is difficult to understand the biological phenomenon clearly, because the chemistry of water revels much about the metabolism of the ecosystem (Basavaraja Simpi et al., 2011). It also serves agricultural, industrial and the environmental conditions, such as topography, water movement, stratification, oxygen, temperature and nutrients characterizing particular water mass in addition the composition of its biota (Karande, 1991). Distributions of nutrients are mainly based on the season, tidal conditions and freshwater flow from land source. The comprehensive ways in which man affect aquatic ecosystems is through altering nutrient dynamics (Boostman and Hecky, 1993) and also water quality characteristic of aquatic environment arise from a multitude of physical, chemical and biological interactions (Deuzane, 1979; Dee, 1989). Through runoff nitrogen and phosphorus as nutrients for the growth of aquatic plants enter into lake water or estuary also depends on the concentration limits of nitrogen and phosphorus elements. The use of rivers for various purposes has ended in with pollution for net outcomes of pollution. So, water quality data is needed to integrate the chemical and biological information to evaluate the potential impacts of the freshwater ecosystem.

II. MATERIALS AND METHOD

Study Area

Gadilam river is located in parts of Cuddalore and Villupuram districts of Tamil Nadu, India, and the river flows towards eastward through Villupuram and Cuddalore district and drains in Bay of Bengal. Generally this river is ephemeral which carries only monsoon flood water. The study region(Gadilam river) with longitude of 79°40’ and 79°45’ East and latitude 11°40 and 11°45’ North in 58M/2 of topographic sheet of survey of India. (Figure1). The Gadilam river is bounded by Ponnaiyar river in the north and the Vellar river in the south. The SIPCOT (Small Industries Promotion Corporation of Tamil Nadu) industrial estate with groups of industries that generate multifaceted chemicals and raw materials are discharged along the downstream part of Gadilam, near the coast at Cuddalore (Prasanna 2008). It also receives a large amount of agricultural runoff along with its course. The lower section of the river’s catchment area is predominantly influenced by sugar cane, monoculture and processing, while the upper water course is affected by domestic sewage as well as by wastewater discharge from rural and industrial production.

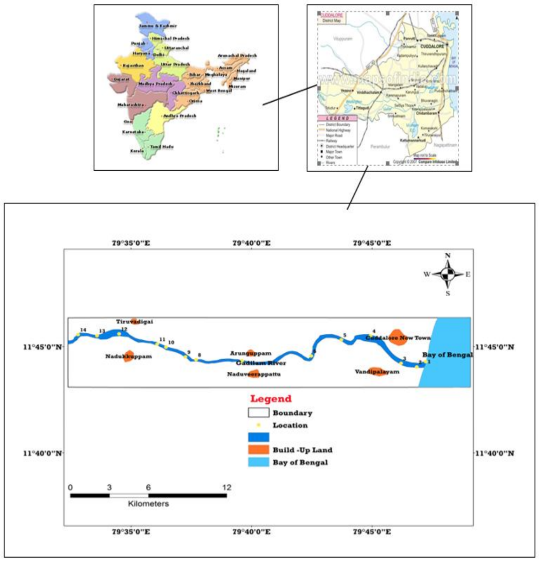

Figure 1,2 Location map of the study region

Sampling

In the study region fourteen sites were identified to collect surface water samples from estuary to Panruti Town. Water samples from each point is collected and stored in clean rinsed polyethylene bottles during summer and winter. The physical parameters like pH, EC and temperature of water samples are monitored in the field using a pre calibrated portable multi parameter kit PC TESTER 35 (Multiparameter) to measure pH, Electrical Conductivity (EC) and Temperature. Other parameters were analyzed using standard procedures (APHA, 1998, Ramanathan, 1992; Ramesh and Anbu, 1996). Calcium, magnesium, and chloride were determined by a titrimetric method and sodium and potassium were determined through flame photometry (ELICO CL 378). Sulphate, phosphate, and nitrate were estimated by spectrophotometer (HACH DR6000).

III. RESULTS AND DISCUSSIONS

The results obtained from the water samples of Gadilam River for physicochemical parameters were tabulated and given as pH, Electrical conductivity (μS/cm), Total hardness (mg/l), Total dissolved solids (mg/l), Calcium (mg/l), Magnesium (mg/l), Sodium (mg/l), Potassium (mg/l), Chloride (mg/l), Sulphate (mg/l), Nitrate (mg/l) and Phosphate (mg/l) in Tables 1 and 2. The reported values refer the mean value of water samples collected during summer and winter seasons at different areas along the whole extend of Gadilam River.

Hydrogen ion (pH)

The pH is a measure of acid balance of a solution and is defined as the negative logarithm to the base 10 of the hydrogen ion concentration. Industrial effluents and atmospheric deposition of acid-forming substances can affect the natural acid base balance of a water body. So, the change in pH can indicate the presence of certain effluents, particularly when measured and recorded continuously, together with the conductivity of a water body. The pH of most natural waters is between 6.5 and 8.5, although lower values can occur in dilute high organic content and higher values in eutrophic waters, groundwater brines and salt lakes (Deborah Chapman 1992). The pH values in summer is 8.5 - 9.7 with an average of 9 and in winter ranges from 8.1 - 9.2 with an average of 8.5. Hydrogen ion is one of the important parameters to determine the acidic and alkaline nature of water. The increased pH value is prominent in river mouth during summer when compared to winter throughout the river. The higher proportion of pH is by the influence of seawater and high biological activity by the uptake of CO_2 by photosynthesizing organisms (Govindasamy et al., 2000). The low pH value is the influence of flood water and mixing up of fresh water all along the river (Prabha Devi, (1986) (Table 1 & 2).

Electrical conductivity (EC)

Electrical conductivity is directly related to the concentration of ionized substance in water and may also be related to problems of excessive hardness or other mineral contamination. The high electrical conductivity indicates a larger quantity of dissolved mineral salts making it inappropriate for drinking (Srivastava et al., 1996). The hydro-chemical study of electrical conductivity indicates an increase in concentration of major ions in the non-monsoon seasons (Benerjee and Gupta 2010). The measured values of electrical conductivity in the study region is 457 mhos/cm to 1732 mhos/cm with an average of 979.6 mhos/cm in summer and 307 mhos/cm to 1415 mhos/cm with an average of 786.2 mhos/cm in winter (Table 1 & 2). It has been observed that the electrical conductivity value in summer is higher and observed in downstream part than the summer values. The influence of EC is by saline water intrusion, anthropogenic activity, tidal action, mixing of saline water and similar findings is also Manikannan et al., (2011).

Total hardness (TH)

Total Hardness (TH) is to determine the water quality suitable for domestic, industrial or agricultural purposes by the presence of excess of Ca, Mg and Fe salts. In the study region TH values vary from and in winter ranges from 113.10-376.3 mg/l with an average of 264.6 in summer and in winter 92.76-

305.73 mg/l, with an average of 211.2 (Table 1 & 2). It is observed that most of the sites having quite high hardness in summer. The utmost hardness during summer is similar with the reports of Vaishali et al., (2013). The total hardness in the study region exceeds the permissible limit set by WHO (1990), however the increase in hardness is due to the decrease in water volume during summer and increase in the rate of evaporation at an elevated temperature and also by mixing of other waste water Vaishali et al., (2013). (Table 1 & 2).

Total dissolved solid (TDS)

Total dissolved solids (TDS) are the measure of combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. The measured values of total dissolved solids in the river Gadilam ranged from 322 to 991 mg/l with an average of 646.3 mg/l in summer and 527 to 1063 mg/l with an average of 789.3 mg/l in winter (Table 1 & 2). The accredited amount is by the addition of ions by weathering and leaching of non-resistant minerals from rocks (geogenic), even though through the influence of anthropogenic component existing in the study area. The total dissolved solids of surface water were in reduced levels in summer and increased level in winter season is because of runoff. Verma et al. (2012) have observed that the large amount of dissolved solids is through high osmotic pressure. The higher amount of solids recorded in winter season could be attributed due to the effluent discharge as evidenced by Ushamary et al. (1998) in the Paravanar river.

Calcium

The calcium (Ca^{2+}) is an essential nutritional elements for humans and the optimum concentration of Ca^{2+} is required to prevent cardiac disorders and for proper functioning of metabolic processes. The average calcium observation in water samples ranges from 21 to 48 mg/l, with an average of 38.8 in summer and 20 to 72 mg/l with an average of 51.8 in winter. However, low concentration of calcium was observed during summer (48 mg/l) and winter (72 mg/l). In Indian River water minimum concentration of calcium is reported as (30 mg/l) in both summer and winter (Table 1 & 2). Hence when compared to global average, it is suitable for aquatic systems (Sarin and Krishnawamy 1984). An elevated range of calcium is noticed in the downstream part in winter and least value in summer at Thiruvandhipuram & Narimedu in upstream part due to stagnant fresh water present in the study region. Calcium naturally occurs in water and the abundance of calcium in water is its natural occurrence in the earth's crust and also due to salinity intrusion (Figure: 3 & 4).

Magnesium

Magnesium concentration in the water sample ranges from 9.82- 45.30 mg/l, with an average of 28.09 during summer. In winter, the values are 13.56 – 47.89 mg/l, with an average of 32.80 mg/l. The natural absorption of dissolved magnesium in rivers is from 0.85mg/l to 12.1mg/l. (Meybeck, G. et al., 1996, 1992) (Table 1 & 2). However, elevated range of magnesium is in downstream part from river mouth to Pathirikuppam and Muthunarayanapuram. In general magnesium is commonly present in natural waters as Mg^{2+} and along with calcium they contribute hardness to water. Magnesium also arises principally from the weathering of rocks containing Ferro magnesium minerals and from some carbonate rocks. It is also reported that high magnesium values may be from soil erosion or to some extent by high density of phytoplankton (Maulood 1989, Hassan 2010). The phytoplankton may be transported by terrestrial sediments during winter, which increase or influence the concentration of Mg in the surface water in the estuary of the study area. (Figure: 3 & 4).

Sodium

Sodium level in water samples ranges from 15.9-76.10 mg/l, with an average of 39.11mg/l during summer. In winter, the sodium value is 24.70- 78.24 mg/l, with an average of 47.51 mg/l. This clearly indicates that the atmospheric recycling is the main source for sodium and is less influenced by physical weathering (Subramanian, 1987). A natural range of dissolved sodium in rivers is from 8mg/l to 25.3mg/l (Meybeck, G. et al., 1992, 1996) (Table 1 & 2). The values of sodium concentration are dominant in winter seasons along downstream part (Pathirikuppam and Arungunam). It is noted that's, natural waters contain sodium, since sodium salts are highly water-soluble and it is most abundant elements on earth. Here in the study area, seawater intrusion and sea level variation can also result in higher absorptions. Concentrations of sodium in natural surface waters vary considerably depending on local geological conditions and wastewater discharges. (Figure: 3 & 4).

Potassium

Potassium concentration in the study area highlights the values from 32 - 74 mg/l, with an average of 53.50 mg/l during summer, but in winter it ranges from 48 - 86 mg/l, with an average of 68.60 mg/l (Table 1 & 2). Natural ranges of dissolved potassium in river water are from 0.5mg/l to 4mg/l as per (Meybeck, et al., 1992, 1996). Gradual increase in potassium value is high in downstream and low in upstream area. It is noted that potassium is usually found in the ionic form and the salts are highly soluble, it readily incorporate into mineral structures and accumulated by aquatic biota, as it is an essential nutritional element. However, potassium salts are widely used in industry and in fertilizers for agriculture. In the study area potassium salts enter freshwaters ecosystem from industrial discharges and run-off from agricultural land that can increase sodium concentration during winter from retrial flow in to the river channels. (Figure: 3 & 4).

Chloride

Chloride distribution ranges from 156 - 264.30 mg/l with an average of 203.80 mg/l during summer. At the same time, during winter the chloride is distributed from 174.60 – 289.63 mg/l with an average of 227.6 mg/l (Table 1 & 2). Natural ranges of dissolved chloride in rivers ranges from 0.6mg/l to 25mg/l (Meybeck, et al., 1992, 1996). The chloride accumulation is high during winter than in summer at downstream. Chloride in water is by industrial sewage effluents, agricultural, road run-off, irrigation drains, and salt-water intrusions, in arid areas and in wet coastal areas. Seasonal fluctuations of chloride concentrations in surface waters can occur. These drains into the river through run off, which indicate chloride concentration in the study area. (Figure: 3 & 4).

Sulphate

Naturally occurring sulphates in the study area exhibits the value ranging from 1.1 - 3.2 mg/l, with an average of 2.11 mg/l during summer. In winter, the value ranges from 1.6 – 3.5 mg/l, with an average of 2.6 mg/l (Table 1 & 2). In general the natural ranges of dissolved sulphate in river are 2.2mg/l to 58mg/l. (Meybeck, G. et al., 1992, 1996). High value is identified in winter season at downstream part of the study area. The moderate values are obtained in downstream part of the study area. Sulphate is naturally present in surface waters as SO42-. It arises from the atmospheric deposition of oceanic aerosols and fossil fuel burning. The leaching of sulphur compounds either as sulphate minerals, gypsum or sulphide minerals such as pyrite from sedimentary rocks. The river basins is dominated with rock weathering processes and anthropogenic activities such as fertilizers from it could be influencing the high concentrations of sulphate in river water (Figure: 3 & 4).

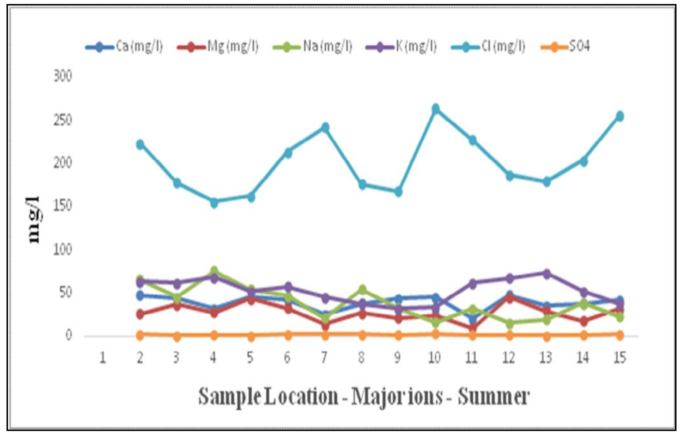

Figure 3. Distribution of Major ions - Summer

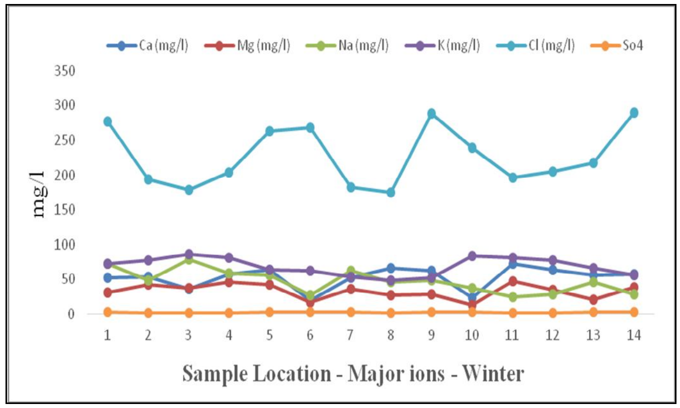

Figure 4. Distribution of Major ions – Winter

Nitrate-nitrogen

Nitrate-Nitrogen concentration in the study area highlights the values from 15.62 - 84.37 mg/l, with an average of 46.30 mg/l in summer and 17.8 – 78.64 mg/l with an average of 44.2 mg/l during winter seasons (Table 1 & 2). Natural ranges of dissolved nitrate in rivers ranges from 0.05 mg/l to 0.2 mg/l as per M. Meybeck, G. et al., (1992, 1996). The value is high in winter season particularly in mid-stream. The high nitrogen content is an indicator of organic pollution results from the added nitrogenous fertilizers, decay of dead plants and animals, animal urines, feces, etc. They are all oxidized to nitrate by natural process and hence nitrogen is present in the form of nitrate. The increase in one or all the above factors is responsible for the increase of nitrate content (Rahman 2002). The surface water contamination is due to the leaching of nitrate present on the surface with percolating water. (Fig: 5 & 6).

Phosphate

The Phosphate concentration in the study area ranges from 0.58 – 2.76 mg/l, with an average of 1.36 mg/l during summer and in winter the values ranging from 1 – 3.3 mg/l, with an average of 1.9 mg/l. (Table 1 & 2). The phosphate distribution of the study area during summer and winter highlights that higher concentration is identified in river mouth and Arungunam due to agricultural wastage and industrial wastage disposal. The low value noted in mid-stream from Naduveerapattu to Thiruvadigai (Fig: 5 & 6). The external sources brings phosphorus to estuaries are from domestic sewage and industrial effluent particularly from fertilizer plants producing phosphate fertilizers.

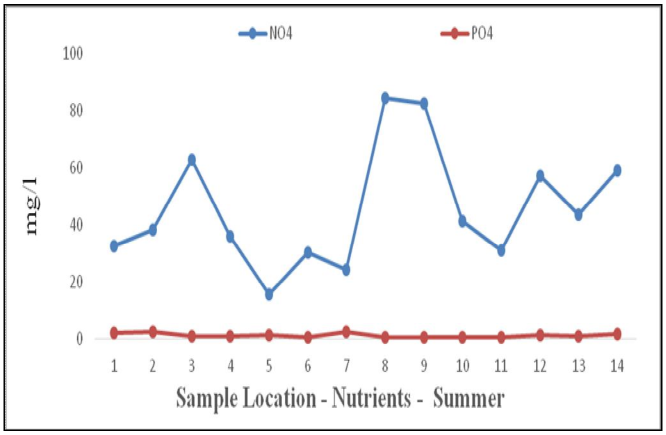

Figure 5. Nutrients – Summer

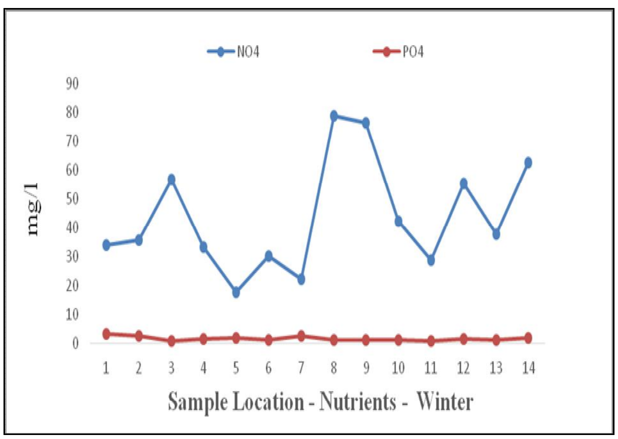

Figure 6. Nutrients - Winter

IV. CONCLUSION

The seasonal variation pattern of surface water samples, which highlights the diverse parameters were found to be influenced in two seasons. All the parameters values give a fluctuated proportion in winter season than in summer season. The irregularity in monsoon precipitation and low water flow influences that variability in some parameters. The concentration variation in physico-chemical variables in the present study areas is subjected to wide spatial and temporal variations. It is concluded that other than the discharge of industrial effluents and domestic sewages, rainfall is also a criteria for the significant cyclic phenomenon in tropical countries that brings almost essential changes in the physical and chemical characteristics of the estuarine and coastal environments.

Table 1. Physical chemical parameter & Nutrients of water sample in summer

	PH (mg/l)	EC (µ mhos/cm)	TH (mg/ l)	TDS (mg/ l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	Cl (mg/l)	SO_4	Nutrients	
											NO_4	PO_4
1	8.2	1400	228.57	980	48	26.48	66.4	64	223.4	2.89	32.78	2.03
2	8.1	1371.4	261.74	960	44	37.01	45.9	62	178.65	1.48	38.46	2.76
3	8.2	1415.7	197.47	991	32	28.65	76.1	69	155.98	1.98	62.96	0.96
4	8.6	1302.9	296.22	912	46	44.2	54.6	52	162.4	1.1	36.35	1.05
5	8.1	357.1	242.76	650	42	33.6	47.3	58	214.1	2.56	15.62	1.38
6	9.2	763	114.04	504	26	14.4	21.9	46	242.56	2.32	30.64	0.62
7	8.2	667	207.75	690	38	27.5	55	38	176.34	2.35	24.32	2.58
8	8.7	528	198.56	825	44	21.6	32.9	32	168.52	1.78	84.37	0.58
9	8.9	307.1	215.86	515	46	24.6	16.9	34	264.3	3.2	82.45	0.74
10	8.4	571.4	92.76	400	21	9.82	32.1	62	227.48	2.2	41.28	0.87
11	8.5	321.4	305.73	525	48	45.3	15.9	68	187.6	1.66	31.33	0.68
12	8.1	460	211.52	322	36	29.64	19.9	74	179.86	1.2	57.34	1.52
13	8.3	551.4	170.19	386	38	18.34	39	52	203.71	2.2	43.65	1.01
14	9.2	840	236.77	368	42	32.14	23.7	38	256.34	2.65	59.17	1.74
Min	**8.1**	**307.1**	**92.8**	**322.0**	**21.0**	**9.8**	**15.9**	**32.0**	**156.0**	**1.1**	**15.62**	**0.58**
Max	**9.2**	**1415.7**	**305.7**	**991.0**	**48.0**	**45.3**	**76.1**	**74.0**	**264.3**	**3.2**	**84.37**	**2.76**
Ave	**8.5**	**786.2**	**211.2**	**646.3**	**38.8**	**28.0**	**40.0**	**53.4**	**203.8**	**2.116**	**46.294**	**1.366**

Table 2. Physical chemical parameter & Nutrients of water sample in winter

	PH (mg/l)	EC (mhos/cm)	TH (mg/ l)	TDS (mg/ l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	Cl (mg/l)	SO_4	Nutrients	
											NO_4	PO_4
1	8.7	1600	258.45	993	52	31.33	72.5	72	276.5	2.96	34.12	3.32
2	9.2	1471.4	309.95	973	54	42.67	48.98	78	193.47	2.2	35.68	2.68
3	8.5	1732.7	240.68	1063	36	36.75	78.24	86	178.62	2.41	56.7	1.08
4	9.2	1602.9	335.73	987	58	46.52	58.5	82	203.78	1.67	33.18	1.58
5	8.7	457.1	335.69	730	64	42.85	55.8	64	263.73	2.86	17.75	2.03
6	9.7	783.7	117.45	802	20	16.45	27.48	62	268.47	2.69	30.14	1.34
7	8.9	867	279.65	730	52	36.5	62.1	54	182.34	2.78	22.45	2.72
8	9.1	748	275.00	945	66	26.83	46.5	48	174.56	2.24	78.64	1.24
9	9.2	627.1	271.73	735	62	28.47	48.7	52	287.86	3.46	76.32	1.36
10	8.8	751.4	113.10	630	23	13.56	37.6	84	239.58	2.56	42.16	1.37
11	8.7	531.4	376.35	723	72	47.89	24.7	82	196.52	2.31	28.92	1.01
12	8.5	630	299.89	527	64	34.12	28.61	78	204.5	1.64	55.3	1.87
13	8.7	721.4	227.54	583	56	21.35	46.54	66	217.84	2.63	37.65	1.49
14	9.5	960	303.34	618	58	38.62	28.94	56	289.63	3.33	62.48	2.2
Min	**8.5**	**457.1**	**113.1**	**527.0**	**20.0**	**13.6**	**24.7**	**48.0**	**174.6**	**1.6**	**17.8**	**1.0**
Max	**9.7**	**1732.7**	**376.3**	**1063.0**	**72.0**	**47.9**	**78.2**	**86.0**	**289.6**	**3.5**	**78.6**	**3.3**
Ave	**9.0**	**979.6**	**264.6**	**789.3**	**51.8**	**32.8**	**48.0**	**68.6**	**227.6**	**2.6**	**44.2**	**1.9**

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