A study of the composition of well waters in and around Bapatla

By

M. R. BALAKRISHNAN, B. A., B. Sc., (Ag.) Lecturer in Chemistry

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D. NARAYANA RAO, B. A., B. Sc., (Ag.)

Assistant in Chemistry, Agricultural College, Bapatla.

PART I.

With the starting at Bapatla, in July 1945, of the second Agricultural College, one of the prime considerations was to ensure a continuous uninterrupted supply of water for the College laboratories and for the residential hostels. At Bapatla the soil is sandy, and the water table is very high, being almost within 2 feet from the surface during the rainy months and about 8 to 10 feet in the summer. A common feature of the tract is the presence of a number of '*doruvus*' scattered within a few yards' distance of each other. A *doruvu* is a shallow excavated depression about 8 ft. deep, the cost of getting one ready being within Rs. 10 to 15. These are the sources of irrigation, which is done by splashing, for crops, like paddy and tobacco nurseries, ragi, brinjals, chillies and other vegetables raised round about Bapatla.

At the time the building and site were acquired for the college, there were a few *doruvus* of this type within the premises, with built-up parapet walls. One of these, near the hostel was decided upon to supply water to the new college. A pump was installed in this well and water pumped to overhead tanks of the college building to meet the needs of the college laboratories and the hostel. It was soon found that the well was not able to cope up with the demand for a continuous supply of water; the water in the well got exhausted within four hours and a sufficient interval had to be allowed for percolation, before pumping could be started again. Proposals were therefore contemplated to increase the water supply, either by deepening the well or by digging some more wells. As a preliminary to such deepening it was considered desirable to have an idea of the composition of the water of some of the wells in the locality and of the effect of such deepening on the concentration of salts. A start was made with three wells in the college compound, one of which was the hostel well itself; the analytical data pertaining to them are given below.

Once again it will be seen that sodium chloride is an important constituent; magnesium chloride was also found in varying amounts and the *doruvus* with the largest amounts of sodium and magnesium chloride (samples III and IV of table) were those found near the alkaline patches. Considering that the '*doruvus*' were near each other, (i. e., within an area of about 30 cents) the data showed much variation in composition, but it was found that the *doruvus* on the western side had a lower concentration than those on the east.

Following this, a number of '*doruvus*' and wells were examined outside the college area, in various parts of Bapatla town and the same observations were confirmed; viz., a wide variation in composition in wells within a short distance of each other, and the presence of magnesium chloride in varying amounts in the water of most of the wells.

In the meanwhile, the Industrial Engineer had been addressed to carry out boring trials within the college compound to locate, if possible, the most copious source of water supply. He started his work in the summer of 1946 and advantage was taken of his boring apparatus to obtain samples from different depths and to carry out analyses on them. Five spots within the college were examined.

I. Bore Trial: In the sweet potato plot near the students' hostel and close to the eastern boundary fence. (About 200 yards east of the college).

II. Bore Trial: On the eastern side of the pond near the dairy (About 150 yards E. S. E. of college).

III. Bore Trial: Near the college bus stand—(About 50 yards S. E. of college).

IV. Bore Trial: Near the gas house, (about 50 yards N. W. of the college).

V. Bore Trial: On the western side of the dairy pond (about 80 yards E. S. E. of the college).

At each spot a sample of water was drawn as soon as water appeared, noting at the same time the depth below ground level; thereafter, a sample was drawn for every successive 2 feet depth bored; up to a depth of 30′. In one of the spots (III) samples of soil were also drawn at every depth along with water, for later analysis. In all the spots it was noticed that upto the depth examined, namely 30′, the soil was only sandy; no rock, either weathered or unweathered was noticed. Altogether 70 samples were examined and the results are presented in appendix I. It will be seen from the figures, that in all the five borings, there is a sharp and sudden rise of total soluble salts, below a depth of 16 feet from ground level. Again magnesium salts increase in concentration,

only below this depth. Generally the upper layers (i. e., above 15′) contain 40 to 50% of calcium salts, 0 to 10 of magnesium salts and 40 to 50 of sodium salts.

The following conclusions are possible from the data presented: 1. It is not safe to go beyond a depth of 16′ feet in this soil, in an attempt to increase the supply of water. 2. The best place to locate a well is near the III Boring. As we go east or north, the salt content increases. In this boring, the total soluble salt content is the lowest, as seen from the comparative table below.

	Total Soluble Salts parts per 100,000 Content at Appearance of water.	39′ depth.
I Bore Trial	57	360
II Bore Trial	50	250
III Bore Trial	41	232
IV Bore Trial	46	390
V Bore Trial	110	280

In addition to this low soluble salt content, magnesium salts are very low in amount, the chloride being found only after a depth of 18 feet is reached. 3. A number of shallow wells, none of them deeper than 15′, would be the best way of providing an adequate supply of water for the college and the best place to locate these wells would be near the spot where the III Boring was made and all the wells could be connected together by a pumping installation.

In addition to the 70 samples from the above boring trials, samples from existing *doruvus*' were drawn in the new area proprosed to be acquired on the north-east side of the students' hostel. In these samples, the chloride content alone was determined, since the number of samples was large and it was felt that a complete analysis need not be taken up unless the chloride content warranted it. It was found that the amount of chlorides was abnormally high in all these samples indicating a correspondingly high salt concentration. It was felt that a boring trial in this area would not lead to the location of good water. The results confirmed further, the findings of the boring trial, namely that as we go farther and farther from the college in a north and an easterly direction, the salt content generally increases.

The presence of magnesium chloride in the Bapatla wells is characteristic. References* to literature show, that near the sea coast, tidal influence even through the soil layer has been known to affect the composition of water sources up to a distance of 15 miles—and it is possible that in Bapatla which is 4 to 5 miles from the sea, a similar

*The examination of waters and water supplies: (Thrush, Beal and Suckling, 5th Edition, by B. V. Suckling, 1944, J. & A. C. Churchill Ltd., London.

influence is exerted the consequence is the presence of magnesium chloride. There seems to be some justification for this for in the several wells examined, it was found that as we go further away from the sea, not only do total soluble salts decrease, but magnesium chloride is very low or completely absent. Amongst nearly 300 samples examined, the best water was found in a disused well in the new area proposed for acquisition for the college farm on the Guntur road. The analysis of that water is given as it is interesting: Calcium bicarbonate—13·72, sodium sulphate—24·10, sodium bicarbonate—4·10, sodium cholride—2 23. Total soluble salts—41·2.

With a total soluble salt content of only 41 parts per 100,000 with no magnesium chloride and very small amounts of sodium chloride, this well is unique amongst those examined in and around Bapatla. It is situated in a "*Pattimannu*" area and about 7 miles from the sea and a mile further off still, is a big drain leading from the Krishna canal. During the rainy months, most of the outlying area gets submerged under water.

Another well within Bapatla town, worth mention amongst those examined is the one in the taluq office compound. This also showed on analysis low total soluble salts (46 parts), low sodium chloride (22 parts), and was completely free from magnesium chloride.

PART II.

While the analytical data outlined above showed the best place to locate a series of wells for college supply and that it is not safe to go beyond a depth of 15 feet it was considered desirable to pursue the investigation and accumulate data, to have an idea of seasonal variations. It was not possible to do this in all the spots examined due to limitations of time, space and equipment in the laboratory. It was decided to concentrate on two chosen water sources within the college compound, draw samples every month and analyse them. For this purpose the hostel well and a pond near the college dairy were selected. The first sample was drawn from these on 24—2—1947 and since then 25 rounds of sampling have been finished up to date, the interval between any two rounds being roughly about a month. Care was taken to draw the samples on the same dates from the two sources.

The analytical data pertaining to these 25 rounds is furnished in appendix II.

From the data it is seen that:—

1. The hostel well water has a higher soluble salt content (130–140 parts for 100,000) than the dairy pond (about 90 parts).
2. The hostel well water has a higher sodium chloride content (55 to 65 p. p.) than the dairy pond (30 to 45).

3. Calcium bicarbonate is also higher in the hostel well (40—45 p. p.) than the dairy pond (15 p. p. m.)

4. The most characterastic difference however is the complete absence of calcium sulphate and magnesium chloride in the dairy pond while the hostel well contains appreciable amounts of these salts, especially magnesium chloride.

5. Magnesium sulphate is also high in the hostel well water (25 p. p.) while it is either low or absent in some months in the dairy pond.

6. As against this, the dairy pond has appreciable amounts of sodium sulphate, which is absent in the hostel well.

The two sources are within a hundred yards of each other, but show such wide variations. While the hostel well gets periodcally pumped for supplying water to the college, the draw is not so great in the dairy pond, the water from which is taken by pots only, for the use of the dairy shed or for splash irrigation of the plants grown near by. It is possible that the hostel well gets its supply from deeper percolation, while the dairy pond which has a large surface area, gets its percolation water from nearer the surface. This might account for the difference in composition between the two waters.

It is also seen that while there is not much seasonal variation in both the sources, the hostel well water is more or less constant not only in its total soluble salts, but also in its calcium and sodium salts; on the other hand, the dairy pond is showing a tendency for a rise in concentration. It may be mentioned in passing that it has been the experience in Bapatla, that newly dug wells are sweet and used for drinking purposes, but gradually get saline with lapse of time. In the beginning they get their supply from surface percolation, and when this gets exhausted, a deeper spring is perhaps the source and this is influenced by the proximity to the sea. The dairy pond, which has so far not been used, is passing through a stage, when the salts are gradually increasing and will finally reach a constant figure. If a pump is also installed in the dairy pond, and the draw of water greater than now, this might result sooner. It is proposed to continue the analyses in monthly intervals for several seasons more to elucidate this aspect.

PART III

The work out lined in parts I and II referred mostly to the analysis of well waters either in or in close proximity to the College. The wide variations found within a short distance of each other required further intestigation. The Principal, Sri P. V. Ramaiah, suggested following up

the work with a study of the sand or any geological, strata at the bottom of the wells, in addition to analysing the water. With this object, a number of wells not only in Bapatla but as far away as Chinnaganjam were taken up for study.

Along with the drawing of water samples, samples of soil, or sand or weathered rock, found at the bottom of the well were also drawn for later examination. Below are given the analytical data referring to three well waters drawn from Chinnaganjam.

		Railway Station water supply reservoir.	A doruvu near the outer semaphore reputed to be good water.	A newly excavated doruvu about 1 mile north of the Railway Station.
Calcium Bicarbonate	...	15·39	12·14	3·62
Sodium Bicarbonate	...	...	...	4·76
Sodium Chloride	...	12·69	9·94	9·48
		28·02	22·08	17·86

All the three wells were found to be extremely good, containing low total soluble salts, low sodium chloride and no magnesium chloride at all.

Chinnaganjam is an important watering station for all trains on the main line, 25 miles from Bapatla. It is also on the sea coast and it is surprising that the water should be so good. It is however, on a different longitude from Bapatla which is more to the north east. As a matter of fact the sea has receded and Bapatla itself is on a curve of the coast line.

Samples of sand collected from the Chinnaganjam wells have been preserved for later complete chemical and mechanical analysis, but microscopic examination revealed an interesting feature. As in Bapatla no rock was met with in Chinnaganjam at the bottom of the wells, the soil being also sandy. But the sand of Chinnaganjam seen under the microscope, showed *smooth, rounded* and slightly coloured particles. The Bapatla sand particles on the other hand were angular, sharp and jagged and white in colour. The Bapatla sand seems to have been formed by the receding of the sea while the Chinnaganjam sand shows the erosive action of ruuning water. A number of smooth, white flat pebbles collected at the bottom of these wells also shows this. Perhaps there is an underground spring located in the longitude of Chinnaganjam. When time and facilities permit, it is proposed to follow up this work by examining a number of water springs between Chinnaganjam and Bapatla. Included in this study, will be the analysis of waters for irrigation and drainage channels which traverse this area.

To Sri C. R. Sreenivasa Ayyangar the Principal of the College who first suggested this work, and to Sri P. V. Ramiah the present Principal, who has been giving valuable suggestions and guidance during the progress of the work our thanks are due. Our thanks are also due to the other assistants who have been helping us in the analytical portion of the work mentioned in the paper.

APPENDIX I

Depth in feet	Heads of Analysis; per 100,000 (to the nearest integer)								
	$Ca(HCO_3)_2$	$CaSO_4$	$Mg(HCO_3)_2$	$MgSO_4$	$MgCl_2$	$NaHCO_3$	Na_2SO_4	NaCl	Total
				No. I—Bore Trial					
10	16	12	...	5	6	...	...	9	48
12	16	...	...	...	...	...	16	15	47
14	21	13	...	2	9	...	...	20	65
16	41	15	...	8	17	...	...	57	138
18	40	3	...	19	4	...	...	74	140
20	46	4	...	10	...	...	12	88	160
22	53	17	...	19	21	...	...	90	200
24	54	12	...	39	25	...	...	133	263
26	69	...	4	39	40	...	...	130	282
28	77	10	...	57	35	...	...	141	320
30	75	...	...	67	17	...	...	196	355
				No. II—Bore Trial					
7	39	1	...	...	...	...	...	9	49
9	29	17	...	...	5	...	...	11	62
11	36	10	...	...	9	...	...	13	68
12	43	11	...	...	13	...	...	24	91
14	34	...	14	...	...	...	...	54	102
16	36	...	13	10	4	...	...	27	90
18	53	...	10	26	...	...	...	103	192
20	61	18	...	31	40	...	...	102	252
22	54	32	...	35	47	...	...	116	284
24	54	31	...	31	51	...	...	106	273
26	58	24	...	38	37	...	...	135	292
28	54	18	...	38	56	...	...	112	282
30	49	20	...	15	74	...	...	89	247
				No. III—Bore Trial					
5	28	...	...	...	...	4	...	9	41
6	30	...	...	...	...	4	...	9	43
7	32	...	...	...	...	3	...	9	44
8	22	...	...	...	...	...	...	12	34
9	34	...	...	...	...	...	...	19	53
10	25	...	...	...	...	...	...	18	43

APPENDIX I—*contd.*

Depth in feet	Heads of Analysis; per 100,000 (to the nearest integer)								
	$Ca(HCO_3)_2$	$CaSO_4$	$Mg(HCO_3)_2$	$MgSO_4$	$MgCl_2$	$NaHCO_3$	Na_2SO_4	NaCl	Total
11	22	...	...	...	...	16	7	44	89
12	24	...	...	...	...	18	12	43	97
13	32	...	...	...	...	13	14	51	110
14	31	...	10	...	...	...	10	55	106
16	44	...	12	20	...	...	8	55	139
18	52	...	9	28	10	...	...	86	185
20	49	...	10	26	10	...	...	89	184
22	52	...	11	27	18	...	...	82	190
24	49	...	17	28	12	...	...	90	196
26	49	...	20	28	7	...	...	95	199
28	50	...	12	32	...	...	21	104	219
30	56	...	8	39	9	...	...	120	232
				No. IV—Bore Trial					
5–7	20	3	...	...	...	...	...	23	46
7–9	20	5	...	...	...	...	...	25	50
9–11	23	...	...	...	...	8	3	25	59
11–13	49	14	...	13	16	...	...	83	175
13–15	36	12	...	13	13	...	...	40	114
15–17	56	21	...	38	28	...	...	70	213
17–19	56	28	...	31	36	...	...	22	173
19–21	56	21	...	28	19	...	...	42	166
21–23	57	...	...	45	...	...	22	60	184
23–25	53	3	...	56	17	...	...	145	274
25–27	42	20	...	48	11	...	...	176	297
27–29	41	17	...	54	15	...	...	203	330
29–30	49	19	...	63	11	...	...	173	315
				No. V—Bore Trial					
5–7	23	...	...	...	...	35	12	12	112
7–9	23	...	...	...	...	34	12	46	115
9–11	27	...	...	...	...	29	12	46	114
11–13	23	...	...	...	...	40	14	46	123
13–15	47	9	...	31	26	...	...	26	139
15–17	56	9	...	43	39	...	...	19	166
17–19	52	7	...	53	11	...	...	59	182
19–21	49	7	...	55	9	...	...	59	179
21–23	52	1	...	68	7	...	...	132	260
23–25	45	14	...	64	11	...	...	122	256
25–27	45	3	...	64	...	...	16	146	274
27–29	46	2	...	74	...	...	14	146	282
29–30	45	...	4	66	...	...	24	139	278

APPENDIX—II

the Hostel Well and the Dairy well

water samples from

APPENDIX—II

Analysis of water samples from the Hostel Well and the Dairy well
Agricultural College, Bapatla.
Parts per 100,000 (rounded to the nearest integer)

Date of sampling	$Ca(HC_3)_2$		$COSO_4$		$Mg(HCO_3)_2$		$MgSO_4$		$MgCl_2$		Na_2SO_4		Na Cl		Total.	
	H.W.	D.W.	H.W.	D.W.	H.W.	D.W.	H.W.	D.W.	H.W.	D.W.	H.W.	D.W.	H.W,	D.W.	H.W	D.W.
24—2—47	44	9	2	absent	absent	13	16	2	11	absent	absent	...	71	27	144	51
2—4—47	48	9	6	,,	,,	11	9	..	12	,,	,,	11	63	35	138	66
1—5—47	39	11	7	,,	,,	13	11	...	21	,,	,,	9	49	27	120	66
2—6—47	57	20	...	,,	,,	13	13	...	10	,,	,,	11	57	59	137	133
4—7—47	35	14	2	,,	,,	17	10	...	4	,,	,,	12	56	45	107	88
22—8—47	43	14	...	,,	,,	5	5	...	...	,,	,,	15	81	39	129	73
29—9—47	49	20	8	,,	,,	3	16	14	13	,,	,,	6	80	32	166	75
27—10—47	37	20	14	,,	,,	3	7	14	18	,,	,,	6	62	32	138	75
30—11—47	35	20	16	,,	,,	11	3	13	26	,,	,,	9	49	52	129	105
5—12—47	36	21	15	,,	,,	2	5	17	21	,,	,,	...	56	40	133	80
20—1—48	50	17	7	,,	,,	14	11	11	13	,,	,,	9	46	39	127	90
23—2—48	53	18	10	,,	,,	6	3	4	21	,,	,,	18	63	42	150	88
19—4—48	47	15	6	,,	,,	4	16	11	2	,,	,,	10	68	51	139	91
21—5—48	45	8	11	,,	,,	...	8	17	12	,,	,,	11	56	31	132	67
30—6—48	55	17	5	,,	,,	4	38	3	...	,,	,,	30	88	76	186	130
5—8—48	49	16	10	,,	,,	...	...	...	...	,,	,,	10	77	57	136	83
9—9—48	36	26	18	,,	,,	...	...	...	...	,,	,,	23	68	62	122	118
9—10—48	45	21	10	,,	,,	...	14	...	15	,,	,,	21	63	52	147	116
2—11—48	42	14	6	,,	,,	...	12	...	11	,,	,,	22	63	55	134	105
2—12—48	39	17	1	,,	,,	...	11	...	20	,,	,,	22	51	40	132	98
31—12—48	45	22	6	,,	,,	15	28	...	...	,,	,,	39	74	44	153	121
31—1—49	40	14	4	,,	,,	22	17	7	7	,,	,,	14	61	50	129	107
28—2—49	42	13	6	,,	,,	24	18	...	43	,,	,,	17	18	54	127	98
31—3—49	43	11	10	,,	,,	29	21	...	9	,,	,,	23	70	83	153	146
2—5—49	38	11	7	,,	,,	31	16	...	7	,,	,,	24	37	73	105	143