SECTION-IX

GENERAL

Fifth Indian Expedition to Antarctica, Scientific Report, 1988
Department of Ocean Development, Technical Publication No, 5, pp. 457-464

Mineralising Snow-Melt Water

B.K. BANERJEE

Defence Materials and Stores Research and Development Establishment, Kanpur-208013

Abstract

In Antarctica, due to poor thirst drive and lack of taste in the local freshwater, the water needs of the body tend to get neglected. Synthetic mineral tablets were developed by the Defence Laboratory, Jodhpur to restore the taste to snow-raelt water. The treated water was subjected to a practical user trial in Antarctica during the Fifth Expedition with favourable results. Most of the expedition members liked the taste of the mineralised water and found it satisfying.

Introduction

Certain minerals (chemical elements) play an important role in fundamental life processes. They are essential, like proteins, carbohydrates, etc., for nutrition, energy, and normal functions of the body. The mineral nutrients, numbering *17* elements (Na, K, Mg, Ca, S, Cl, P, Cu, Zn, Se, Cr, Mo, F, I, Mn, Fe and Co) found essential for man are (NAS, 1980; WHO, 1973) all contained in requisite amounts for specific functions in different constituents of the human body. However, as a direct consequence of the life processes and associated body functions, the body content of the minerals is continually depleted by excretions for removal of metabolic waste and maintenance of body temperature. All such excretions are accompanied by a simultaneous loss of water and heat from the body. It is, therefore, imperative to replenish the minerals, as also water (which forms the bulk of the body fluids, instrumental in sustaining the life processes), lost in excretions on a daily basis (Tables I and II) for the normal functions and energy of the body. Mineral nutrients (grouped under major and trace elements according to their body contents and needs) are found in foods (Kirschmann, 1979) and drinking water (W.P.C.B., 1982) (mostly the major elements in the latter and in very much lower concentrations than in foods.)'

The mineral needs of the human body can be met by a proper choice of foods (Table III) wherein the minerals occur in proportion to body requirement. However, the water needs of the body tend to be neglected in Antarctica, partly

Table I. Mineral content and requirement of the human body (Adult, Male)*

Element	Body content mg/kg body wt.	Daily requirement mg/day
Major		
Na	1,500- 1,600	1,100-3,300
K	2,000- 3,500	1,875-5,625
Mg	270 - 500	350
Ca	14,000-20,000	800
S	1,600- 2,500	adequate with adequate protein; (1500)**
CI	1,200- 1,500	1,700-5,100
P	11,000-12,000	800
Trace		
Cu	1.0-2.5	2.0-3.0
Zn	33 - 50	15
Se	0.2 -0.3	0.05 -0.2
Cr	0.06 - 0.2	0.05 - 0.2
Mo	0.1 -0.5	0.15-0.5
F	37	1.5-4.0
I	0.2 - 0.4	0.15
Mn	0.2-4.0	2.5 -5.0
Fe	60-66	10
Co	0.02	0.003

*National Academy of Sciences, 1980 **Bycov, 1960

Table II. Estimated water balance of the human body (Adult, Male)*

Ingestion		Loss	
Drinks	1,350 ml	Lungs	500 ml
Food	900 ml	Skin	700 ml
Oxidation of food	450 ml	Urine	1,400 ml
		Faeces	100 ml
Total	2,700 ml		2,700 ml.

*Thorpe *et al* 1964

due to the poor thirst drive there, and partly due to the lack of taste in local freshwater. Drinking water (domestic supply) owes its familiar taste to minerals (mainly the major nutrients) originating in continental freshwaters (Livingstone, 1963; White *et a]*., 1963). Snow-melt water, on the contrary, is almost completely free of foreign matter, and water from the Maitree (Priyadarshini) lake was also found to be poor in these minerals (Table IV).

Synthetic mineral tablets were developed by Defence Laboratory, Jodhpur (one of the DRDO establishments) to bring the mineral content and taste of snow-melt water close to those of drinking water. If the taste of the snow-melt

Table III. Some food source of mineral nutrients*

Element	Source	Element	Source
Major		Trace	
Na and Cl	Common salt Pickle Canned Veg. *eg.* Avial (bean, carrot, peas)	Cu Zn Se	Wheat germ Chicken Mango Onion Coconut
K	Potato Peas Peanuts	Cr	Corn Wheat germ Paprika
Mg	Wheat bran Whole corn Shrimp	Mo	Milk Whole grain cereals
Ca	Whole milk Cheese Mustard greens	F I Mn	Tea Iodized salt Carrots Peanuts Brown rice
S	Chicken Egg Fish	Fe	Wheat bran Wheat germ
P	Peas Peanuts Chicken	Co	Chicken

*Kirschmann 1979.

water treated with these mineral tablets (hereinafter referred to as mineralised water) were acceptable to the members of the Indian Expeditions to Antarctica, it could promote water consumption among them, enhancing water replenishment and partially supplementing the mineral needs of the human body in Antarctica.

To determine whether the expedition members liked the taste of mineralised water and were satisfied with it, a practical trial was held in the Fifth Antarctic Expedition (summer of '85-86) with favourable results. The independent views of members were recorded individually in this summer experiment described below.

Materials and Method

Snow-melt water, drawn from the kitchen tap at Dakshin Gangotri, was used for the experiments, which were carried out partly at Dakshin Gangotri and partly on the ship on departure. The temperature of the water was around + 19°C at both places.

The mineral tablets contained all the major nutrients except phosphorus, and only iodine (not present in drinking water) among the trace nutrients. Each tablet provides, in a litre of snow-melt water, a concentration of Na^+, K^+ and

Table IV. Chemical analysis of water from. Maitree (Priyadarshini) Lake*

Component		Quantity ppm (mg/1)
Cations	Na^+	l.O
	K^+	1.0
	Mg^{2+}	Trace
	Ca^{2+}	Trace
	Fe^{3+}	Absent
	Heavy metals	Absent
Anions		
	SO^{2-}	
	Cl^{-4}	2.8
	F^-	0.05
	NO^-_3	0.05
	HCO^-_3	5
	co^2_3-	NIL
TDS		12
Total hardness		Trace
	PH	6.8
E. Coli		Absent

*Analysis carried out by Defence Laboratory, Jodhpur.

Cl^- comparable to that of domestic drinking (tap) water (Table V). The tablets readily dissolve in snow-melt water (in the proportion used, vide infra) in about half an hour at room temperature without stirring, providing potable water.

The summer experiment with the mineral tablets was in the form of an opinion poll after a single trial. The sole aim of the experiment was to ascertain whether or not the taste of the mineralised water was acceptable to the members of the expedition.

The trials were carried out in five instalments, three at Dakshin Gangotri Station (DGS) and two on the ship. A total of eightyfour members took the test, thirtytwo at DGS, and the rest on the ship. For trials on the ship, snow-melt water was obtained from DGS for the purpose. Each member was given about 300 ml of plain snow-melt water and the same quantity of mineralised water (one tablet to a litre of water), separately. After they had drunk the two different waters, the members were asked to fill in a questionnaire proforma each, expressing their opinions independently. The participants gave their views on the basis of

Table V. Comparison of mineral contents of tap water* and mineralised water

Mineral Content	Tap water, ppm		Mineralised water, ppm (one tablet/1)
Cations			
	Na^+	50	53.7
	K^+	3	2.9
	Mg^{2+}	16	3.6
	Ca^{2+}	42	20.7
	NH_4	0.1	
Anions			
	SO^{2}_{3-}	56	14.0
	cr	66	75.4
	r	—	o;8
	HCOJ	198	79.9
	POJ" total	8.1	—
	POij- (non (jrtho-phosphates)	0.3	"
	NOJ	•5	—
	NOJ	0.15	
	cof-	0.1	
	SiO^{2-}	29	—
TDS		382	251.0

•Sttte Water Pollution Control Board Publication No. 9 (1972), California.

just one trial. Some members refused to take the test and some others could not give any definitive reply to questions on different aspects of taste and preference.

Results and Discussion

Of the eightyfour members who took the test, fiftyeight (ca 69%) liked the taste of the mineralised water, and fiftyseven (ca 68%) felt satisfied with the mineralised water. Fiftyone members (ca 61%) liked the taste of the mineralised water and also felt satisfied with it; one member found a distinct pleasant taste in it.

Thus, the taste of the mineralised water is positively liked by more than 69% of the members who took the test, and about 61% liked its taste and also felt satisfied with it. On an objective assessment of the recorded replies, it can be said that the taste of the mineralised water was acceptable to the majority of the members of the Expedition.

Opinion was more evenly divided on the question of similarity between the tastes of the mineralised water and domestic drinking water. Forty members (ca 48%) said they were similar in taste, fortythree (ca 51%) said they were not, while one member did not know. Specific differences between the two waters were identified by recorded remarks by some members with a keener observation. Six members noted that on dissolving, the mineral tablets made the mineralised water a bit turbid. Four others found the mineralised water to have a faint smell, a metallic taste, a particular mineral in excess, and to be more salty than domestic drinking water, respectively.

These remarks, though few in number, are nevertheless significant and suggestive as they were made without any prior knowledge of the contents of the mineral tablets; they help to explain, at least partially, the difference between the tastes of the mineralised and drinking waters noted by fortythree members. Drinking water does not normally contain any trace nutrients, but every litre of the mineralised water contains iodine in a quantity (Table V) which is more than five times the daily dietary requirement (Tabel I). This could well be the primary reason for the difference in the tastes of the two waters. Small excesses of mineral nutrients in drinking water, however, are not harmful though they may affect its taste. This is illustrated by the composition (Tabel VI) of the waters of the centuries old mineral springs at Carlsbad, which are believed to have a healing effect inspite of their "slightly acid and saline" taste (Encl. Brit, 1957). The concentration of iodine would perhaps have to be several thousand times (estimated toxic limit 500 mg/kg body weight; Lewis and Tatkin, 1979) its present value in the mineralised water (Tabel V) to be harmful.

Improvement of the clarity and taste of the mineralised water await further development work on the mineral tablets. However, possible inhibition due to the twin problems of turbidity and taste of the mineralised water could be more than offset by a knowledge of its usefulness, as is the case with commercial aerated waters with the so called "isotonic salts" in them which are positively

turbid. The Carlsbad waters are freely used for drinking inspite of their abnormal taste, evidently because of the knowledge of their beneficial effects. One member who took the test actually remarked that he preferred the mineralised water (over snow-melt water) "from a knowledge of its mineral contents".

Table VI. Mineral content of water from mineral spring (sprudel) at Carlsbad*

Mineral Content		Qty ppm (mg/1)
Anions	Na^+	1544
	K^+	83
	Mg^{2+}	27.6
	Li^+	1.2
Cations		
	SO^2_4	1731
	ci-	632
	HCO3	1092
	CO_2	966
TDS		5111
With traces of As, Sb, Rb, Se, Sn and organic substances.		

*Source: Encyclopaedia Britannica, Vol. 4.

A definite conclusion regarding the usefulness of the mineral tablets in Antarctica can be arrived at only after more extensive and repeated user trials, followed up by a study in collaboration with a physician to determine their physiological efficacy. The persistently low humidity of Antarctica enhances the loss of water from the body and correspondingly enhances the need for water replenishment. Water ingestion as drinks and plain water must exceed (it should perhaps be about thrice, U.S.A.R.P., 1985) that reflected in Table II viz., 1.35 1 as drinks to maintain the water balance of the body. A motivation, stronger than the bare acceptability of taste, supported by requisite education is necessary to promote water consumption in Antarctica, in view of the paucity of thirst there. A knowledge of the physiological efficacy of the mineralised water may provide that motivation.

Acknowledgements

Thanks are due to Sq. Ldr. S.K.S. Puri and Maj C.M. Adya (now Lt. Col.) for carrying out the initial part of the trials with mineral tablets at DGS. Thanks are also due to Dr. Ram Gopal, Scientist 'E' for help in analysing the water from the Maitree (Priyadarshini) lake at DLJ. The help and facilities provided by Shri M.K. Kaul, Leader of the Fifth Indian Expedition to Antarctica are

gratefully acknowledged. Grateful thanks are due to Dr B;V. Ramani, Director, DMSRDE, for his active interest in the DRDO work in Antarctica, encouragement and general guidance.

References

BYKOV, K.M. (1960): Text Book of Physiology, Foreign Language Publishing House, Moscow.

Encyclopaedia Britannica, (1957), v. 4.

KIRSCHMANN, J.D. (1979): Nutrition Almanac, McGraw Hill, New York.

LEwis, SR R.J. AND TATKIN, R.L., (Eds.) (1979): *Registry of Toxic effects of chemical substances,* NIOSH, PHSC for Disease control, Washington, D.C.

LIVINGSTONE, D.A. (1963): Mean chemical composition o£ river water in the world, *U.S. G.S. Prof. Pap.* 440-G, 28.

NAS (1980): Recommended dietary allowances. Food and Nutrition Board, Washington, D.C,

S.W.P.C.B. (1972): Studies of Waste water Reclamation and Utilisation, *SWPCB Pub. No. 9,* Sacramento, California.

THORPE, W.V., BRAY, H.G AND JAMES, S.P. (1964): *Biochemistry for medical students* J and A Churchill Ltd., London.

USARP (1985): *Survival in Antarctica.* NSF Div. Polar Programs, Washington, D.C.

WHITE, D.E., HEM, J.D. AND WARING, G.A. (1963): Chemical composition of ground water from various kinds of rock, *U.S.G.S. Prof. Pap.* 440-F.

WHO Expert Committee; (1973): *Trace Elements in Human Nutrition,* WHO Tech. Rep. Ser. No. 532