ASPECTS OF WATER PROBLEMS IN THE MALTESE ISLANDS

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ABSTRACT

This paper touches on some aspects of problems Malta faces in producing potable water to meet its requirements. Statistics are reproduced showing the accelerated increase in water production and consumption.

Groundwater will always remain the most economic source of production. However, in view of the small area of the Maltese Islands, supply of ground water has to be curtailed so that water quality will not deteriorate further. Malta has had perforce to resort to the more costly production through artificial means. Multiflash distillation was introduced in 1966 and recently in 1983 the first Reverse Osmosis Plant at Ghar Lapsi came into operation. Obviously from an economic view point these are much more costly sources of production and possibly are to be used sparingly.

On the other hand Malta, as a developing nation, has to produce water of good quality to cater for requirements of the Touristic and Industrial Sector and to enhance the standard of living of its population.

1 INTRODUCTION

Ground water will always remain the cheapest production source. However, in view of the relative small area of the Maltese Islands 316 km^2 and the average rainfall annually of 500 mm, production of ground water is conditioned to actual availability, keeping in view mainly chloride and nitrate content. Ground water is mainly produced by pumping from the mean sea level aquifer from underground galleries and boreholes.

2 WATER BALANCE

TABLE A Shows the water balance for the main island - Malta

TABLE B Shows annual water production for both islands, Malta and its smaller sister Gozo.

1986 WATER BALANCE (MALTA) *

Table A

	Input		**%**	
A	Precipitation	124 800 000 m^3/year	100.0	
B	Surface Run-off	7 400 000 "	5.9	
C	Evapotranspiration	87 400 000 "	70.0	
D	Natural Recharge	30 000 000 "	24.1	
E	Recharge from Leaks	4 900 000 "	3.9	
F	**Total Recharge**	34 900 000 "	28.0	

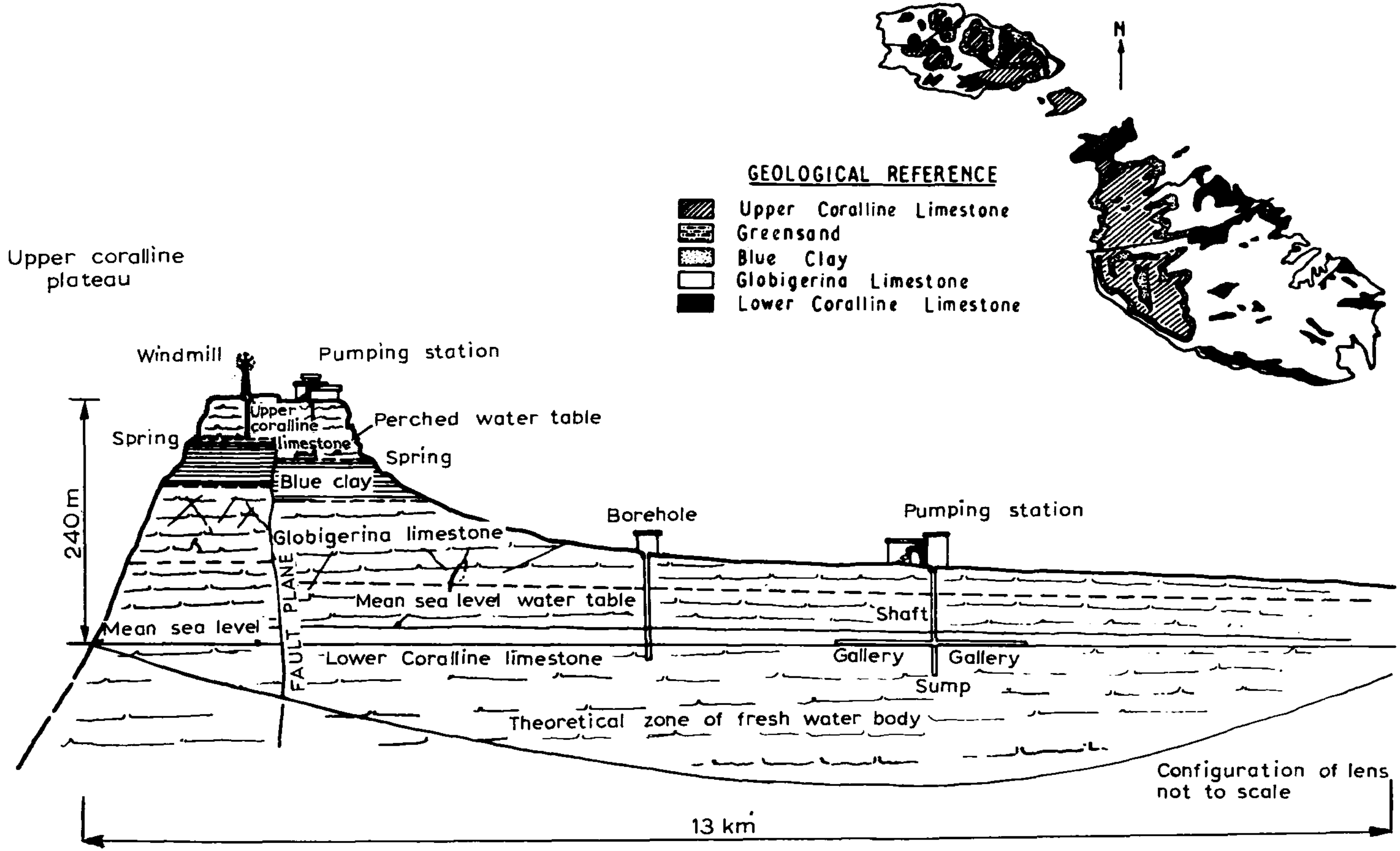
	Public Extractions - Output		**% of Recharge**	
G	Gallery Extraction (mean sea level aquifer)	11 186 000 m^3/year	32.0	
H	Borehole Extraction	6 471 000 "	18.6	
I	Galleries (perched aquifer) (springs)	562 900 "	1.6	
J	**Total Public Extraction**	18 219 900 "		52.2
K	Private Extraction	3 600 000 "	10.3	
L	**Total Groundwater Extraction**	21 819 900 "		62.5

* Excluding the island of Gozo

The mean sea level aquifer is the major source of ground water in Malta. There are two systems of exploitation of this source: a) underground galleries dug at sea level, and radiating from a central shaft, b) boreholes which are sunk to a depth of 18 m below mean sea level depending on the geological conditions. According to the Ghyben Herzberg principle, the mean sea level aquifer consists of a lens shaped body of fresh water floating on saline water. The lens configuration arises from the different densities of fresh water and sea water, and implies the existence of a hydraulic gradient from the land towards the coast. This is physically confirmed by the occurrence of various coastal springs which appear in the vicinities of the Maltese coasts, and which have been mapped in detail during an infrared aerial survey carried out in the late 60's.

Overpumping of the mean sea level aquifer accelerates sea water encroachment, with a consequential rise in salinity. This problem is particularly notorious in those areas where underground galleries intersect fissured rock regions with a relative high vertical permeability.

GEOLOGICAL MAP OF MALTA AND GOZO



3 PATTERN OF WATER PRODUCTION

Table 'B' shows water production for significant years and includes both Malta and Gozo.

Table 'C' shows the percentage of production from different sources for the same years.

From these tables the following salient points emerge.

(a) Water production in Malta and Gozo has more than doubled in the span of twenty years from 15.4 Mm^3 in 1966 to 31.6 Mm^3 in 1986.

(b) In 1966 all water production came from ground water and springs. During 1986, 66.9% of production came from these sources and the rest 33.1% was obtained by artificial means, that is, distillation and reverse osmosis.

(c) Production of ground water from Pumping Stations and Boreholes was 14.9 Mm^3 in 1966, whilst it increased to 20.5 Mm^3 in 1986.

(d) Pumping Stations' production shows a decrease of 14.6% while Borehole production increased by 502% during the same period.

Table B

ANNUAL WATER PRODUCTION COMPARISIONS Mm^3

FOR SIGNIFICANT YEARS

	Extracted from Underground (galleries)	Boreholes	Springs (Perched Aquifer)	Distillate	RO Plants	Total
1966	13 401 800	1 506 900	494 400	-	-	15 403 100
1969	11 740 600	2 025 700	828 900	2 630 600	-	17 255 800
1970	12 883 000	2 076 500	572 300	3 093 700	-	18 625 500
1972	11 138 700	1 806 400	806 700	4 672 000	-	18 423 800
1976	13 068 000	5 083 700	729 800	3 047 000	-	21 928 500
1986	11 448 200	9 074 400	562 900	1 331 600	8 970 000	31 555 500*

* includes 168 400 Mm^3 water imported by sea tankers as a temporary measure during summer

Table C

PERCENTAGE OF PRODUCTION OF SOURCES

	Pumping Stations	Boreholes	Springs (Perched Aquifer)	Distillate	RO Plants	Other	Total
1966	87.0	9.8	3.2	-	-	-	100
1969	68.2	11.8	4.8	15.2	-	-	100
1970	69.2	11.1	3.1	16.6	-	-	100
1972	60.5	9.8	4.4	25.3	-	-	100
1976	59.6	23.2	3.3	13.9	-	-	100
1986	36.3	28.8	1.8	4.2	28.4	0.53	100

4 WATER PRODUCTION COST

Water Production Cost of the various sources work out as follows per 1 m^3 in US $.

	Running Cost	Amortisation	Total
(a) Distilled Water	1.17	-	1.17
(b) Reverse Osmosis Water (Lapsi)	.75	.45	1.20
(c) Ground Water (Boreholes & Galleries)	.26	.03	.29

(a) - No amortisation is calculated in respect of the distillers as they have already exceeded the span of their useful life.

Cost of water production from Boreholes is shown at Table 'D' which also shows their various components.

Table D

COST OF WATER PRODUCTION FROM BOREHOLES ONLY

	Volume Produced	Expenses $	% of Total Cost	Cost per 1 m^3 $
10% of Capital Expenditure for period 1972/86 to cover amortisation	60.3 Mm^3	1 079 000	8.2	.018
Running expenses based on 1986 production Electricity	6.5 Mm^3	1 192 500	83.2	.183
Chlorination expenses (Chlorine & wages)		19 600		
Crane expenses (Hire of cranes & wages)		49 800		
Transport expenses (Van expenses and fuel)		54 800		
	6.5 Mm^3	124 200	8.6	.019
Total cost per 1 m^3			**100.0**	**.220**

The following remarks are also made in respect of Ground Water.

From the preceding Table 'D' it emerges that Electricity components represent 83% of total costs.

However, Borehole production is included globally under Ground Water Production which also caters for water produced by Pumping Stations.

The overall production costs of ground water include the two main components, that is,

Labour Costs 44% US$ 0.11/m^3

Electricity Costs 41% US$ 0.10/m^3

It is remarked that a substantial labour force, working 24 hours daily on shift system attends at all the Pumping Stations. Consequently, labour costs are significant. On the other hand boreholes operate on their own and are checked periodically to ensure whether corrective action is necessary.

5. WATER TARIFFS AND CONSUMPTION BY CATEGORY

Table E

Domestic (covering 4 months)	US $ Equivalent
Up to 27 cubic metres ---- Lm 1.200	3.52 BLOCK CHARGE
Up to 42 cubic metres ---- 12c1 per 1 m^3	0.35 per m^3
Up to 57 cubic metres ---- 16c8 per 1 m^3	0.48 per m^3
Excess ---- 25c per 1 m^3	0.73 per m^3
Commercial	
Lm 5 per 57 m^3	14.65 BLOCK CHARGE
Excess 12c per 1 m^3	0.35 per m^3
Farms	
(charged at Industrial rates)	
Tourism	
a) Hotels: 70 c per 1 m^3 up to 14 m^3 per bed	2.05 per m^3
Excess at Lm 1 per 1 m^3	2.93 per m^3
b) Holiday Flats: 70 c per 1 m^3 up to 84 m^3	2.05 BLOCK CHARGE
Excess at Lm 1 per 1 m^3	2.93 per m^3
c) Bars, Restaurants & Nightclubs	
Lm 1.20 up to 10 m^3	3.52 BLOCK CHARGE
70 c per 1 m^3 up to 57 m^3	2.05 per m^3
Lm 1 per 1 m^3 all excess	2.93 per m^3
Industrial	
4c5 per 1 m^3 up to 2270 m^3	0.13 per m^3
Excess at 12c per 1 m^3	0.35 per m^3

Table F

PERCENTAGES OF REGISTERED WATER CONSUMPTION BY CATEGORY

	Domestic	Commercial	Farms	Tourism	Industrial	Others	Total
1967	48.5	13.0	5.5	N.K	13.5	19.5	100
1974	58.5	5.7	5.2	3.9	9.6	17.1	100
1976	53.6	6.1	4.9	5.3	12.0	18.1	100
1979	60.8	5.8	3.6	8.6	12.0	9.2	100
1982	67.8	6.0	2.5	7.4	10.5	5.8	100
1986	63.3	6.9	4.0	6.9	10.4	8.5	100

It is obvious that the water tariffs are too low to cover the average weighted cost of water production which works out at \$ 0.59 per m^3 and distribution costs which are \$ 0.26 per m^3, making a total cost of \$ 0.85 per m^3.

This is particularly true in respect of the Domestic and Industrial tariffs.

It should also be pointed out (Table F) that up to 1979 the consumption in respect of the British Services was shown under 'Others'. (The British Services left Malta in March 1979).

6 ECONOMIC CONSIDERATIONS OF GROUND WATER AND REVERSE OSMOSIS PRODUCTION

From the economic view-point it would naturally be preferable to produce ground water vice Reverse Osmosis Water.

A mathematical model is to be drawn up to arrive at the optimum quantity of ground water that should be extracted without harming the mean sea level aquifer in any way. This would probably result in a reduced availability of ground water. On the other hand as regards Reverse Osmosis the raw material - the sea - is there in unlimited volume. However, the electricity component of its production cost (36%) and the cost of membranes (which are a sine qua non) are substantial. It is not impossible to consider optimistically a vast improvement in technologies which could reduce these costs.

In the present circumstances, Malta as a developing nation, can ill afford such relatively high production cost sources, but it has not other choice.

Consumption of potable water is increasing at an annual rate of 1 Mm^3. This means an increase of 8 litres per capita daily. Malta's population is 340 000. This represents a higher standard of living and improving health standards. Besides, water is an essential component of the Infrastructure of Maltese Economy, where Tourism and Industry are always expanding. To meet the increasing demand for water, further production will have to be obtained from Reverse Osmosis Plants.

7 CONLUSIONS

(a) Groundwater Availability

All experts, both local and foreign, are of the opinion that Malta's main ground-water production points are over-exploited. On the other hand there could be areas where higher production could be achieved and a concurrent reduction made from other points. The necessity thus arises of having a mathematical model of the aquifer so that the maximisation of this comparatively cheap source is achieved without harming the aquifer. Action is envisaged in this respect.

(b) Additional Requirements

As the Maltese economy expands, mainly in the touristic and industrial sectors, and with an improving standard of living the demand for water is bound to increase. Even if the maximisation of ground water production is achieved, additional requirements have to be obtained through the more costly artificial means, that is, either through (a) flash distillation or (b) reverse osmosis plants. At present (b) appears to be the most suitable for Malta's requirements. The siting of two other Reverse Osmosis Plants on the shores of the island has been planned. These will be erected at stratagic points of the distribution system.

(c) Reducing losses from leakages

This problem has been a running sore for many years.

Water lost through leakages has exceeded 30% consistently. To this a hefty percentage of water unaccounted for is to be added.

Plans are in hand to improve the master meter network through zoning so that particular areas where heavy losses are occurring can be pinpointed and consequently subjected to intensified search. In this connection the Water Research Engineering company of the United Kingdom had been entrusted recently with preparing a review of leakage control policy and practice in Malta, under the auspices of the Commonwealth Fund for Technichal Cooperation of the Commonwealth Secretariat. The final report submitted is being considered. Progress in this respect will obviously be of great help in cost-benefit terms. It was estimated that the annual cost of US$ 300,000 could yield a benefit of US$ 5,000,000 if successfully implemented.

(d) More rational pricing of water services

The current pricing system is now outdated. The average cost of water production has risen since 1983 as a result of the increased proportion of artificially produced water to that of ground water.

In 1969 the rate was 1:6 whilst it now is, roughly, 1:2.

Consequently, in order to curtail unnecessary use it is felt that a review of the present tariff structure should be carried out, and a greater public awareness created. It should be borne home that finally it is the tax-payer who has to pay for subsidised production from his own pockets.

This is a matter of Socio-Political import and as such devolves on the policy-makers.

The following percentages showing what the water subsidy represents in various economic terms are reproduced.

(a)	Total Government Expenditure	2,9 %
(b)	Gross Domestic Product	1.0 %
(c)	Private Consumption Expenditure (including Tourism)	3.9 %