REPORT

ON THE

WATER SUPPLIES OF MALTA,

1912.

BY

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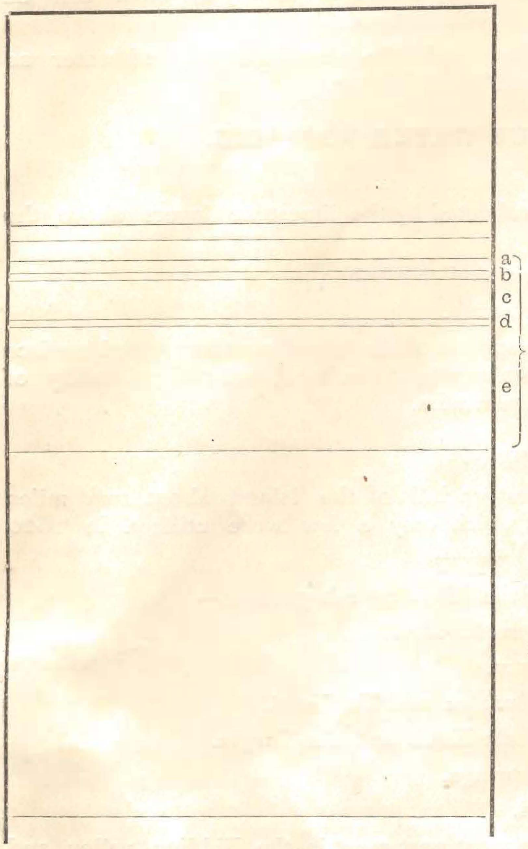
PART I. DESCRIPTIVE.

GEOLOGY OF THE ISLAND.

1. In a report of this description a short survey of the geology of the Island is of great importance.

2. The rocks of Malta consist of a series of nearly horizontal layers of crystalline, granular or earthy limestones, of a bed of green sand and a bed of stiff clay or marl. These are all of a sedimentary origin.

3. These layers are as follows :—



1	Upper coralline limestone... ...	about 300 feet.
2	Green sand...	from 0 to 35 feet.
3	Blue clay	from 1 to 40 feet.
4	Globigerina limestone	about 250 feet.
5	Lower coralline limestone... ...	about 500 feet.

4. The strata can thus be described:—

1. Coral limestone, reddish-white calcareous rock mostly compact and hard, but sometimes changed into a yellow sandstone. Original thickness exceeds 100 feet.

2. Layer of soft yellowish-red sandstone or loose sand; thickness varies from 8 to 20 feet, has greenish-black grains intermixed with the yellow sand, abounds in organic remains differing from those of **1**.

3. Thick bed of marl or clay of a dark blue or light grey sometimes light brown, not stratified, contains crystals of gypsum and occasionally nodules of sulphur. The marl contains a few organic remains which have served as nuclei to irregular nodules of iron pyrites.

4a. White calcareous sandstone immediately subjacent to the marl into which it quickly passes, 20 to 30 feet thick.

4b. Bed of fine grained sandstone 15 to 20 feet thick, of a reddish-white and sometimes grey colour, contains foraminifera.

4c. Deposit 30 to 50 feet thick, pale yellow calcareous sandstone with nodules of a flinty texture viz:—chert, in which are fish scales; it varies much in quality—in some parts thinly stratified, but more generally assumes an unstratified character, sometimes used for building, liable to exfoliate on exposure to weather.

4d. Bed 2 to 8 feet thick, calcareous sandstone containing irregular nodules mixed with casts of shells and other organic remains, fish teeth and vertebrae.

4e. Lowest portion of sandstone 40 to 50 feet thick. Building stone (at Luca) unstratified.

5. Yellowish-white, semi-crystalline, alternating with course sandstone apparently made of minute fragments of coral and shells, 400 feet or more. Used for building purposes (scutella bed).

5. The water bearing strata are all above the third layer (i.e. the blue clay), not because the other layers do not absorb water, but because the blue clay alone stops the water and causes it to flow in streams or come to the surface as springs. Sir John Murray observes in his work on the Geology of the Maltese Islands:—

" The clay is generally watertight so that engineers in search of water stop sinking when they strike this bed. " Were it not for the retentive nature of this bed of clay, Malta and Gozo would have little if any water supply. " At the level of this layer the Maltese run in tunnels to collect water for irrigation and other purposes, and the " famous aqueducts constructed over 200 years ago carry water to Valletta from this layer for a distance of about " 8 miles". The rocks above the blue clay are therefore the natural reservoirs of our rainfall. Owing to this waterproof layer, the water that has filtered through the limestone is collected in sheets and crops out as springs on the clay.

The water which falls on the rock, below which no layer of clay exists, is likewise absorbed but does not form springs. It permeates the rock throughout and if a gallery is cut in this rock at about sea level the water oozes out of the porous stone and dribbles on the floor of the gallery. In this way a certain quantity of water can be collected, proportional to the porosity of the stone and to the surface of rock exposed.

Galleries cut in the white rock to the southwest of Casal Curmi have yielded a plentiful supply of water as will be detailed later on. These are the galleries of Wied-Isseuda and Wied-il-Kbir.

GENERAL DESCRIPTION OF THE VARIOUS WATER SUPPLIES.

6. The Water supplies consist of:—

A. Three separate groups of springs, the water of which is collected by the limestone layers above the bed of clay.

B. A few isolated springs, the water of which is collected in a similar manner.

C. The deep galleries cut in the soft white rock of the lower strata.

7. It will be seen from the above that practically all the water supplies of the Island may be termed surface waters. Although the waters in the galleries are very deep, being practically at sea level, still the possibility of fissures in the rocks themselves must make us consider them as surface waters.

A. 1. The Wignacourt Supply.

8. The first of the three large groups is that existing on the Western hills of the Island about two miles beyond Notabile. This group is made up of a number of springs of which only a few were utilized in 1620 when Grand Master Wignacourt constructed his famous aqueduct to Valletta.

9. This group is named the Wignacourt supply and consists of the following sub-groups:—

Sub-group (1). Consisting of the two springs Ta Baldu and Hofriet-ir-Rizz.

Sub-group (2). The springs of Misrah Suffara and Ta Decozzu.

Sub-group (3). Consisting of three springs Bonua, Wied-il-Buzbiez and Ta Cianti.

Sub-group (4). Consisting of three springs Ghain Kajjed, Ghain Klieb and Tat-Targia.

Sub-group (5). Buzigrilla, Gheriexem, and two other small springs.

Sub-group (6). Another solitary spring named Tal Ghemieri.

10. The waters from the springs of all these sub-groups for the most part meet in the Fiddien valley and are conveyed in pipes to the reservoirs at Attard and finally help to supply Valletta, Floriana, Sliema, St. Julian's, Birchircara, Musta, Gargur, and Naxaro.

A. 2. The Boschetto Supply.

11. The second of the large groups originates on the hill to the south of Notabile, round Verdala Palace. This group is called the Boschetto Group and consists of:—

(1). The spring of Tas-Senia.

(2). The spring of Tas-Sala.

(3). The spring of Ta Rapa.

(4). The spring of Ghain-il-Cbira or Ghirghenti.

(5). The Bishop's springs, three in number.

12. This supply goes to Siggieui, Zebbug, and Curmi, a branch is taken to the Lunatic Asylum and from there to the reservoirs at Tal Kali (Attard).

A. 3. The Fawwara Supply.

13. The third group is the Fawwara supply consisting of three springs originating under the high plateau of Tal Ghalia and Gebel Ciantar to the south of the Island. The springs are :—

(*a*). Tal Lunziata.

(*b*). Tal Fawwara.

(*c*). Ta San Giorg.

14. This water is conducted towards the village of Crendi and distributed to this village and to those of Zurrico, Safi, Luca, Chircop, Tarxien, Gudia, Axiak, and Zeitun and their respective districts.

B. Isolated springs.

15. (1). The water supply of Rabato originates in the galleries cut in the plateau between Rabato and Dingli.

(2). Bur-nuhhala, from a plateau to the north of the Bingemma hills.

(3). Tal Gnien, from the north-west of the Bingemma hills towards Ghain Tuffieha.

(4). Mejjesa, from the cliffs to the north of Ghain Tuffieha.

16. Springs (2) and (3) supply St. Paul's Bay and Mellieha, also partly the Military camp at Ghain Tuffieha.

C. The deep galleries.

17. Armier, Wied-il-Kbir and Wied-is-Isseuda. In the sixties the attention of the Authorities was drawn to a supply of water at the Marsa in a field called "Tal Armier". A pumping plant was fixed and water pumped toward Cospicua.

In 1883 Mr. O. Chadwick, a Sanitary Engineer of repute, was called in to give his advice about the water supply of these Islands. Mr. Chadwick gave his views in a series of reports extending between 1883 and 1888 and the Government adopted most of the recommendations expressed in these reports.

The main gallery runs at practically sea level, from the head of the Marsa along the Wied-il-Kbir and Wied Kirda valleys, and after passing under the high ground east of Zebbug it comes out again into the Wied-Isseuda valley which it follows up as far as Wied Incita where another pumping station is situated. The gallery is 3¾ miles long and is cut in the white rock at a depth varying from 200 to 173 feet. The water in the gallery is pumped up in part by the pumping station at Wied-il-Kbir, and in part by that at Wied-Isseuda.

DETAILED DESCRIPTION OF THE VARIOUS GROUPS.

A. 1. The Wignacourt Supply.

18. Sub-group (1) *Ta Baldu* and *Hofriet-ir-Rizz:—*

Ta Baldu is a small spring originating on the Ta Baldu plateau; this area is under cultivation and there is a senia and several wells in the area. It is a single gallery about 2,600 feet long and 65 feet deep. The pipe goes eastwards and joins that of Hofriet-ir-Rizz. There was a second small spring to this supply but this was cut off as it was objectionable being too near a farmhouse.

19. *Hofriet-ir-Rizz.* This water originates at the end of the gallery, about 1,000 feet long and 50 feet deep running at the eastern edge of a deep depression in the ground which is under heavy cultivation and is known as Hofriet-ir-Rizz. It appears that this water is in reality only the surface water of this highly cultivated area. In winter it is turbid which clearly points to its surface origin.

20. The combined waters of Ta Baldu and Ta Hofriet-ir-Rizz run down to join the Wignacourt supply in the Fiddien valley.

21. Sub-group (2). *Misrah Suffara Spring.* Its collecting ground is the rocky plateau to the north of Casal Dingli. It has two heads; one originates very close to the village of Dingli. The second originates in the rocky soil about 500 yards north of that village. The first head is not piped and is not included in the water supply as its source is not considered satisfactory. The second head is piped and is the principal source of this supply. The gallery is about 4,000 feet long and 70 feet deep, at its head, and winds its way to the Fiddien valley, viâ Ta Baldu hill and Wied Liemu, where it joins the Wignacourt supply. In the gallery there are three small subsidiary springs all piped. This water used to join the water from another spring viz:— Ta Decozzu. This latter spring has a bad catchment area and is evidently a surface water; it was accordingly cut out of the water supply in 1910.

22. Sub-group (3). *Bonua, Wied-il-Buzbiez* and *Ta Cianti:—*

Bonua and *Wied-il-Buzbiez.* These springs have been classed together as they practically tap the same catchment area. This catchment area is the rocky ground between Bieb-ir-Rua and Imtahleb. This ground is sparsely cultivated. The galleries are about 70 feet deep and are some 8,000 feet long. They were cut in 1864 and contain 175 shafts. The waters from these springs, of which there are numerous sources, are conveyed in pipes down to the Fiddien valley to join the Wignacourt supply. The waters from these springs were formerly joined by the Cianti water but this water has now been cut out of the supply.

Cianti takes its origin from the ground south of Bonua from a catchment area which is low lying, highly cultivated and tapped by many wells. The exclusion of this water from the aqueduct was recommended on account of the objectionable character of its catchment area and its sensibility to rain.

23. Sub-group (4). *Ghain Kajjed, Ghain Klieb,* and *Tat-Targia:—*

These springs have for their collecting area the Nigret hill. This is a rocky plateau with moderate cultivation on it and two or three farmhouses. Taken on the whole the character of the collecting ground is good.

Ghain Kajjed originates at the north east part of the hill. It is a short gallery about 165 feet long and 40 feet deep. A farmhouse is situated on the crown of the gallery but the head of the spring is well beyond it.

This water goes to a tank on the Fiddien road whence it is pumped to Nadur on one of the Bingemma hills. From Nadur it is distributed to Imtarfa and the outlying Forts in that area. Part of the Ghain Kajjed water goes to supplement the Rabato supply.

Ghain Klieb. This originates on the centre of the hill and flows in a northerly direction to join the Wignacourt supply. The gallery is fairly long (about 940 feet) and 50 feet deep.

Tat-Targia. This originates also from the centre of the Nigret hill but it runs in a westerly direction and is conducted to Fiddien. It has several small heads; the gallery is about 1,400 feet long and 80 feet deep.

24. Sub-group (5). *Buzigrilla* and *Gheriexem.*

These springs are no longer in the supply. Although near the Ghajn Kajjed spring their catchment area is not the same but is the hill on which Rabato stands. The chemical composition of this water and that of Ghajn Kajjed is different, the former being a considerably harder water. As their catchment area was not satisfactory, being near human habitations and abounding in wells, and as the water was exceedingly sensible to rainfall, both springs were permanently cut off from the supply.

Formerly two small springs named Tar-Randa and Tal Berkuka used to join the aqueduct near the Ghajn Klieb water. Their catchment area was the low lying, highly cultivated fields north of Nigret hill. This area is a bad one and the springs, being very sensible to rain, were permanently cut out of the supply.

25. Sub-group (6). *Tal Ghemieri.* This spring rises at the bottom of the southern aspect of one of the Bingemma hills, known as Ghemieri. The plateau under which it originates is rocky, uninhabited and sparsely cultivated. The gallery is about 770 feet long and 75 feet deep. It is piped to the Fiddien valley where it joins the Wignacourt supply.

A. 2. The Boschetto Supply.

26. *Tas-Senia* originates on the low hills to the west of Boschetto valley. The gallery is not deep, the catchment area is highly cultivated and is tapped by numerous wells. The spring is very sensible to rain. For these reasons this water has been cut out of the supply.

The Springs *Tas-Sala* and *Ta Rapa* take their origin from the hill to the south of the Boschetto valley known as Ta Rapa. Tas-Sala appears at the foot of the hill at the northern aspect. It is a short gallery about 145 feet long and 60 feet deep and the water is very little sensible to rain. Ta Rapa emerges on the easterly aspect of the hill, about half way up its summit. It has two heads. It is a constant spring and little sensible to rain, the gallery being about 265 feet long and 30 feet deep. The Ta Rapa hill is rocky and sparsely cultivated.

Ghajn il Cbira. From the southern aspect and at the foot of Ta Rapa hill, in a valley known as Ghirghenti, the spring of Ghajn-il-Cbira emerges. This spring is not Government property and as it has not been piped it is not allowed to join the water supply.

The Bishop's springs. These are three in number and arise in the valley known as Gnien-il-Cbir. Their catchment area is the high ground to the south of that valley and north of Verdala Palace. They are private property but the Government has the right to use the water when required. The water from these springs is now piped to join the Boschetto supply on its way to Zebbug, near the church of San Blas. The water in the galleries themselves is not piped, however. The hill on which they originate is highly cultivated and is tapped by several wells.

A. 3. The Fawwara Supply.

27. (*a*). *Lunziata.* This spring is the most easterly of the group. The gallery starts near the Lunziata church and extends towards the high and rocky plateau of Tal Ghalia. It is a short gallery, however, and does not reach the face of the cliff. The gallery is to be lengthened to reach underneath this rocky plateau thereby avoiding any pollution from surface waters in the lower ground under the plateau. The gallery is about 50 feet long and 25 feet deep.

(*b*). *Fawwara.* This spring arises about 1,200 yards west of Lunziata spring and the same remarks apply to it.

(*c*). The *San Giorg* gallery is about 1,000 yards north of Fawwara and commences immediately under the high and rocky plateau of Gebel Ciantar. The galleries are deep and extensive and all run underneath this high plateau. Length of gallery about 2,115 feet and depth 90 feet.

28. The combined waters from these springs join together and are piped in an easterly direction to a service tank at Krendi whence the water is distributed to the southern and eastern villages of the Island, Krendi, Mkabba, Luca, Gudia, Zeitun, and the eastern Forts, Benghisa, Delimara, etc. A branch pipe of this supply goes to a tank at Nigret near Zurrico and supplies the villages of Zurrico and Safi.

B. Isolated springs.

29. (1). *The Rabato supply.* Rabato and Notabile have an independent water supply. In 1885, 2,300 feet of galleries were dug through 14 shafts on the plateau which from the Dominican Convent at Rabat extends towards Casal Dingli. Several springs were found and their water was conducted towards a point on the Casal Dingli road where a pumping station was constructed. The water is pumped in a circular reservoir 120 feet above the surface of Rabat and Notabile. When needed, this supply can be supplemented by the Ghain Kajjed pumping station.

(2). The *Bur-nuhhala* spring crops out under the rocky plateau of Bur-nuhhala, one of the Bingemma hills, to the north west of Nadur. The spring is not large and runs in a gallery 230 feet long in which the water has lately been piped from its source. This water is conducted northwards towards Zebbieh and Puales and is intended to supply Mellieha. On its way it supplies Mgiar and St. Paul's Bay.

(3). The spring known as *Tal Gnien* crops out on the south west face of the Ghain Tuffieha cliffs. Its collecting area appears to be the rocky plateau of that district which is only slightly cultivated. The water runs in 225 feet of gallery, lately piped. The water leaves the collecting box in a westerly direction. A 2″ pipe is taken to supply the Ghain Tuffieha camp. A 6″ pipe takes a supply to Pwales where it meets the Bur-nuhhala water on its way to Mellieha. Another 6″ pipe runs to a reservoir close by and hence to the neighbouring fields where it is used for irrigation.

C. The deep galleries.

30. *Armier, Wied-il-Kbir,* and *Wied-Isseuda.* The Armier water is a brackish water which crops up abundantly all over the Marsa plain. Formerly it was pumped at a field called Tal Armier. Later, however, with a view to economy, it was arranged to pump this water at the Wied-il-Kbir station and this station is now intended to pump the water from the galleries cut in the white rock and also the Armier water which is known as the second class water. This Armier water is hard and is not well adapted for domestic purposes ; both bacteriologically and chemically it is objectionable. It is therefore only used as a second class water and it is made to run in special pipes for this purpose. The Armier water is pumped to a reservoir on the St. James' Cavalier opposite the Castille and hence is distributed by gravitation.

At Wied-il-Kbir Pumping Station the arrangement is as follows. There are two pumps, a large one capable of lifting one and a quarter million gallons of the deep gallery water, called first class water, and also a second pump which can lift half a million gallons daily of the second class or Armier water. Unfortunately, however, each of these engines can pump either water and, further, Armier water can be run into the well from which usually Wied-il-Kbir water is pumped. With this arrangement it is possible to have an admixture of the two waters and this is objectionable from a health point of view.

The Wied-il-Kbir water is pumped to a service tank to the north of Luca called *Schinas Reservoir* the capacity of which is about 1 million gallons. From thence it is distributed by gravitation to the three Cities, Verdala Barracks, and Cottonera Hospital and if required it can also be distributed to Valletta. A Naval tank, close to Schinas reservoir, is also fed from this pumping station and is exclusively used by the Naval Authorities.

The Wied-il-Kbir engines, even when working continually, do not exhaust the water collected in the gallery, but can only lower its level to about 9 feet in depth. This shows that apparently with more powerful engines this supply of water could be increased.

The Wied Is-seuda Pumping Station lies at the farthest or south west end of the gallery and can pump water of about ½ million gallons per day. Hard continuous pumping does not affect the level of the water in the gallery, so that here again a more powerful engine would seem to be able to supply a greater amount of water. The water is pumped into a main which goes to Valletta. This main joins the Wignacourt water at about ½ mile east of the Kali reservoirs. When the Wied-Isseuda water is pumped in excess of the requirements of its distribution area it goes into one of the tanks at Tal Kali (Attard).

YIELD OF SPRINGS.

31. The following figures, showing the difference in quantity of the water yielded in winter and summer by the various springs, have been kindly furnished by the Superintendent of Public Works. A year of rainfall somewhat above the average has been chosen.

The figures for the individual springs of the Wignacourt group are not available as the daily yield of water was only registered at the box in the Fiddien Valley through which the total Wignacourt supply passed into the main aqueduct.

As many of these Wignacourt springs which had undesirable catchment areas and showed great sensibility to rainfall have now been cut out of the supply, the difference in the daily yield in winter and summer will be considerably reduced in future.

DAILY MEAN AVERAGE YIELD OF SPRINGS IN GALLONS DURING 1908-09. (RAINFALL 25·110).

Date 1908-09	Fiddien	Sala	Rapa	Senia	Lunziata	Fawwara	S. Giorg
December	160534	48638	15970	20409	18135	16475	38565
January...	656600	48070	16013	110547	23646	23957	41554
February	448833	49966	15865	56488	17152	15697	40736
March	379200	45185	13906	39773	16540	14491	33554
April	311892	48222	14117	32654	17735	15611	36013
	1957059	240081	75871	259871	93208	86231	190422
WINTER	391411	48016	15174	51974	18648	17246	38084
June	185677	45046	12544	19644	16787	15242	33480
July	159159	42680	13042	14625	16248	14194	32880
August	143700	42126	12278	13268	15839	12730	32737
	488536	129852	37864	47537	48874	42166	99097
SUMMER	129512	43284	12621	15845	12958	14055	33032

PART II. ANALYSIS.

32. Up to a few years ago the potability of the water of the Island was judged almost entirely by chemical examination. Some of the waters were condemned on account of excessive hardness, i.e. the Armier and Marsa waters. Other springs such as Gherixiem and Buzigrilla were condemned on account of the excess of organic matter observed, especially after rain. Later on, bacteriological examinations were made on the then recognised lines, and other springs such as Ta Decozzu and Wied Liemu were cut out of the supply as the result of these tests.

The bacteriological examination of these waters became an acute question after the epidemic of Enteric Fever of 1909 which was in all probability due to definite pollution conveyed in some of the galleries and by the Buzigrilla Spring.

33. The present bacteriological examination is based on the lines laid down by Clemesha in his Annual Report of the King Institute, Madras, for 1908.

A practical resumé of this report was made by Firth in the R.A.M.C. Journal of November 1910. Our examinations are conducted on the lines laid down therein, and an attempt has been made to trace the Lactose fermenters present in the waters and place them in their respective groups of importance. It must, however, be borne in mind that Clemesha based his division of Lactose fermenters principally on the factor of the length of time that the waters were constantly exposed in large volumes to the action of sunlight. The waters of Malta are quite different in this respect. As a practical point they are not exposed to the action of sunlight at all, as, for the most part, they run underground from their source till they reach their distribution.

It will thus be acknowledged that the deductions drawn from our examinations of the Lactose fermenters cannot be strictly compared with those of Clemesha, as he says himself that he cannot tell how far his methods are applicable to waters of springs and wells which are not exposed to the direct action of sunlight. These observations also apply to the methods of water analysis adopted at Khartoum and expressed in the 4th report of the W. T. Research Laboratory for the year 1910.

Although the comparison may not be a strict one, a certain comparison can be established, as we have found that in those waters left to stand in a tank (not exposed to light) there is an alteration in the different groups of Lactose fermenters.

The first group is practically non-existent and No. 3 group is more common than No. 2 group.

We therefore think that Clemesha's conclusions in regard to the various groups do, to a certain extent, apply to the Malta waters.

We may further state that during the months that our bacteriological examinations were being conducted there was no outbreak of any water-borne disease at all in the Island, although the waters of several springs, which were being drunk, were shown to contain organisms of the first group.

34. Whatever importance may be attached to the deductions made from the methods of bacteriological and chemical examinations of waters there remains a third factor in regard to them, the value of which outweighs either of these methods. This is the investigation and knowledge of the catchment areas of the various springs and supplies. On this factor hangs the chief evidence for the constant purity or otherwise of the supplies and accordingly the chemical and bacteriological examinations must remain subordinate to it. What then is our local knowledge in this respect? Speaking generally we know:—

(1). That they are surface waters. That is, they originate from rain which falling on certain areas percolates through the soil and comes out as a spring.

(2). We know that these areas are cultivated (sometimes heavily and sometimes sparsely), that these areas contain few inhabited houses, that many of them contain wells which tap the sheet of water of which the spring is a part.

(3). We know that they contain no cess-pits.

(4). We know that the cultivated areas on them are manured, and often very heavily manured.

(5). We know that this manure is principally animal manure of which human excreta may form a part, as it seems to be the custom of the local agriculturist to keep human excreta for this purpose.

(6). We know further that the water from the springs is now piped from its source direct to the consumer. This is of the greatest importance as it eliminates the possibilities of pollution that formerly existed in the channels that run in the miles of galleries and aqueducts, and permits us to judge of the purity of the spring from a study of its catchment area alone independently from the land through which the long galleries of the aqueducts have to pass.

35. The above can be considered to be the general knowledge we possess.

The particular knowledge we aim at possessing with regard to each individual catchment area consists in:—

(1). The nature of the ground, whether rocky and sparsely cultivated, or whether richly cultivated ground heavily manured.

(2). The habitations, if any, on it and the number and character of the wells, if any.

(3). The depth, i.e. through what quantity of rock must the water percolate or filter before it crops out as a spring.

With regard to (3) we meet a very great difficulty, which is the existence of fissures in the rock. It is common knowledge that extensive fissures occur in the rocks of the Island. There is no practical method of knowing whether these fissures exist in any given place and the only indication on which we can rely for their presence is the sensibility of the spring to rainfall. Certain springs, for instance Tas-Senia, Ta Decozzu, Ta Cianti, the catchment areas of which were not considered safe for the reasons mentioned in (1) and (2), were cut out of the supply.

36. It will be seen that the characters of the waters of these Islands differ in many essential respects from those on which Clemesha's report and the report of the W. T. Research Laboratory at Khartoum are based. Our waters are not derived from rivers which flow through large tracts of land inhabited by insanitary people and which may be polluted in their course by sewage, as in India and Egypt. Under ordinary conditions the waters of our springs have to filter through a certain thickness of rock which sometimes is as deep as 200 feet. Our only problem is the condition of the rock through which this filtration occurs. In winter after rain the filtration is not perfect and surface waters may be washed down into the springs unfiltered. Here even simple sedimentation in tanks would safeguard the water, but unfortunately a sufficient number of storage tanks do not exist in Malta.

37. The question of a standard of purity for a water supply is exceedingly difficult and has been made to vary according to different observers in various countries.

In Malta it is not possible to give a uniform standard of purity for the year. In summer when there is no rain and filtration is good the bacterial contents of the waters are low; after rains Lactose fermenters are more in evidence. The chief and most important factor in the water supplies of Malta is the introduction after rain of unfiltered surface waters into the springs. No given standard can be adopted to legislate for this. Fortunately we have a remedy at hand.

38. Having before us the general characters of the waters of the Island, i.e. the possibility of their pollution by human excreta from the catchment areas, we looked round for some effective but cheap method of treating the water so that the likelihood of its pollution might not affect the consumer.

There was a method of treatment in use — namely, by lime, but hitherto that had not been successful in ridding the water of bacteria of an intestinal type.

39. One of us had seen the De Chlor process in use at Reading and thought it possible to use a modification of this method to suit local conditions here. At Reading, where the process is in use, water is treated by Chloride of Lime and the Chlorine is eliminated from the water by means of a filter. The water after treatment is not stored in tanks but goes direct to the mains. Now the Malta water contains very little organic matter and so the quantity of Chloride of Lime necessary to treat it would be far less than that required for the Reading water which is a river water. Therefore by using very small quantities of the reagent and allowing the water to rest for several days, so as to allow any trace of Chlorine to pass away, we thought that a practically sterile water might be given to the consumer free of Chlorine and without having to use the expensive apparatus for the filter.

40. Laboratory experiments were made first of all and as they proved successful, the next experiment was made on No. 3 tank at Attard. A million gallons of water was made to flow at a uniform rate into this tank, so that the tank received the whole million in six days. A solution of Chloride of Lime was run continuously into the water entering the tank, the amount of available Chlorine being carefully estimated at 0·5 parts per million.

Samples of water were taken daily, and always proved to be practically sterile. A slight taste and smell, resulting from the treatment, remained in the water. Another 400,000 gallons of water were therefore added to the tank without treatment and allowed to mingle and remain with the water already in the tank. This was on the 10th day from the beginning of the experiment. Two days afterwards (12th day) the water was quite free from any taste and smell and also proved to be practically sterile. On the following day, that is on the 13th day from the beginning of the experiment, the water was sent into the Valletta mains mixed with the Wied-Isseuda water.

It was evident from this experiment that small as was the quantity of Chloride of Lime used, yet it was still too strong to permit of its use as a working scheme.

No. 1 tank was therefore taken and filled in three days with a million gallons of water at a continuous rate of flow and the reagent (Cloride of Lime) was added in strength of .25 parts per million of available Chlorine. The tank filled in three days and the water was found to be practically sterile. Slight taste and smell were apparent, but in three more days they had completely disappeared and on the seventh day, from the beginning of the trial, the sterile water from the tank was put into the Valletta mains mixed with the Wied-Isseuda water.

A similar experiment was again tried on No. 3 tank and again on the seventh day a sterile water free from any smell and taste was put into the Valletta mains.

41. As these tests proved so successful we were strongly of the opinion that we had here a process by which a practically sterile water could be given to the consumer at very little cost. We were permitted to continue this method of treatment and from that date until the present time the Wignacourt water has been continuously treated. The three small tanks at Attard are used. No. 1 tank is filled with treated water in 4 days. It rests 4 days while No. 2 tank fills, also in 4 days. No. 1 tank is then put into the Valletta mains (taking 4 days to empty). In the meanwhile No. 2 tank stands for 4 days while No. 3 tank is filling. Thus we always have one tank filling, one standing and one going to the Valletta mains.

The treated water has always proved practically sterile (that is Lactose fermenters are absent in 100 c. c.) and the water that has stood in the tank four days has always been free from taste and smell.

The strength of Chloride of Lime varies somewhat but it can be confidently stated that an amount between 6 and 8 lbs. is sufficient to sterilise 1 million gallons of water for all practical purposes.

42. The following figures were obtained from the Public Works Department. Bought in bulk, Chloride of Lime costs:—£10. 10s. a ton, or about 1½d. a pound. The daily supply of water is about 2 million gallons. Therefore the daily cost of a practically sterile water would be between 1/6d. and 2/- a day.

43. We would recommend that suitable arrangements be made to treat the whole water supply to Valletta by the same method.

Valletta is commonly supplied by the Wied-Isseuda and Wignacourt waters, the amount of the latter water supplied daily being from one quarter to one third of the former. As it exists at present, the Wied-Isseuda supply cannot be treated as it is essential that the treated water should stand in a tank for 4 days. We therefore suggest that the main for the Wied-Isseuda water be prolonged as far as the Prise-d'eau, that is the box where the Wignacourt Supply is connected with the reservoirs at Attard. It could then be treated together with the Wignacourt supply and the combined waters, after treatment, sent into any of the tanks at Attard to rest for several days before going to Valletta.

This would necessitate (1) the prolongation of the Wied-Isseuda main for a distance of about 1500 yards. (2) The division of the Santa Maria tank, which has a capacity of 12 million gallons, into say 4 tanks of 3 million gallons each.

44. Once this method of treatment had been applied to the Wied-Isseuda and Wignacourt waters and found efficient, the same method could be adopted for the remaining supplies of the Island.

The application of this treatment would necessitate the construction of additional reservoirs.

We would like to point out, however, that apart from any question of this treatment the provision of reservoirs for water supplies of this description is a sound policy because the waters can thus be brought to one place where they can be distributed at a uniform pressure and where any method of treatment can be readily applied.

45. We would further point out that, if suitable provision be made for this method of treatment, any of the waters of the Island, except brackish waters such as "Tal Armier" and "Ta Gheriexem", could be safely added to the existing supplies. These waters are objectionable for drinking purpose on account of the excess of mineral salts they contain.

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16th April, 1912.

TABLE I. Result of Bacteriological examinations of the various water supplies made between August 1911 and February 1912.

Name of Supply	No. of times examined	No. of C.Cs. in which Lactose fermenters were found	Bacilli identified	Class
Ta Baldu	8	1 c.c. three times	Lactis aerogenes	2
		5 c.c. three times	Cloacae (2)	3
		20 c.c. once	Coli communis (2)	1
		25 c.c. once	Grunthal	3
			Neapolitanus	2
			Acidi lactici	2
Hofriet-ir-Rizz	5	0·5 c.c. twice	No. 75	?
		1 c.c. three times	No. 37	?
			Coli communis (3)	1
			Grunthal	3
			Acidi lactici	2
			Coscoroba	2
			Neapolitanus	2
Misrah Suffara	11	1 c.c. six times	Lactis aerogenes	2
		5 c.c. once	Grunthal (2)	3
		10 c.c. once	Cloacae (3)	3
		25 c.c. twice	Coscoroba	2
		100 c.c. once	Neapolitanus	2
			Acidi lactici (6)	2
Bonua	8	0·1 c.c. once	No. 18	?
		5 c.c. once	Oxytosus perniciosus	1
		10 c.c. twice	Lactis aerogenes	2
		25 c.c. once	No. 109	?
		50 c.c. three times		
Wied-il-Buzbiez	12	1 c.c. six times	Acidi lactici	2
		5 c.c. once	Grunthal	3
		10 c.c. twice	No. 18	?
		20 c.c. twice	Coscoroba	2
		50 c.c. once	Coli communis	1
Ta Cianti	8	0·1 c.c. once	Coli communis	1
		0·5 c.c. once	Neapolitanus	2
		1 c.c. five times	Grunthal	3
		5 c.c. once	Cloacae	3
			No. 79	?
			No. 101	?
Ghain Kajjed	5	20 c.c. once	Lactis aerogenes	2
		25 c.c. once	Grunthal (3)	3
		50 c.c. three times		
Ghain Klieb	8	1 c.c. once	No. 98	?
		5 c.c. once	No. 109	?
		10 c.c. three times	No. 67	?
		65 c.c. three times	Cloacae	3
Tat-Targia	12	1 c.c. once	Neapolitanus	2
		5 c.c. five times	No. 109	?
		10 c.c. twice	No. 36	?
		25 c.c. three times	Grunthal	3
		65 c.c. once	Coli communis	1
			Cloacae	3
			Lactis aerogenes	2
			Coscoroba	2
Ghemieri	4	10 c.c. twice	Neapolitanus (2)	2
		50 c.c. once	Grunthal	3
		65 c.c. once		

TABLE I.—*cont.*

Name of supply	No. of times examined	No. of C.Cs. in which Lactose fermenters were found		Bacilli identified	Class
Tas-Senia	3	1 c.c.	once	No. 67	?
		5 c.c.	twice	Lactis aerogenes	2
				No. 109	?
				No. 8	?
				Coli communis	1
Tas-Sala	4	50 c.c.	twice		
		65 c.c.	twice		
Ta Rapa	4	50 c.c.	twice		
		10 c.c.	once		
		65 c.c.	once		
Ghain-il-Cbira (Ghirghenti) ...	2	1 c.c.	twice	Neapolitanus	2
				Coli communis	1
				Grunthal	3
Bishop's Springs: Tal Mina il Cbira... ...	3	5 c.c.	once	Lactis aerogenes	2
		10 c.c.	twice	Neapolitanus	2
				Grunthal	3
Bishop's Springs: Tal Calcara	3	5 c.c.	twice	Coli communis	1
		3 c.c.	once	Grunthal	3
				Coscoroba	2
Bishop's Springs: Tal Iskof	3	5 c.c.	twice	Coscoroba	2
		20 c.c.	once	Grunthal (2)	3
Lunziata...	3	5 c.c.	once	Coli communis	1
		35 c.c.	once	Coscoroba	2
		150 c.c.	once	Neapolitanus	2
Fawwara	4	10 c.c.	twice	Lactis aerogenes	2
		50 c.c.	twice	Neapolitanus	2
				No. 66	?
				Grunthal	3
San Giorg	4	5 c.c.	once	Lactis aerogenes	2
		10 c.c.	once	Coscoroba	2
		25 c.c.	twice	Grunthal	3
				No. 109	?
				Acidi lactici	2
Rabat	2	5 c.c.	twice	Coli communis	1
Bur-nuhhala	5	1 c.c.	twice	Coscoroba	2
		10 c.c.	twice	Coli communis	1
		20 c.c.	once	Acidi lactici	2
				Neapolitanus	2
				Lactis aerogenes	2
Tal Gnien ta Ghain Tuffieha ...	3	5 c.c.	once	Lactis aerogenes	2
		10 c.c.	twice	Cloacae	3
				Coli communis	1
Mejjesa	2	15 c.c.	twice	Cloacae	3
Armier	5	1 c.c.	five times	Lactose aerogenes (4)	2
				Coli communis	1
				Grunthal	3
				No. 67	?
				Coscoroba	2

TABLE I—*cont.*

Name of Supply	No. of times examined	No. of C.Cs. in which Lactose fermenters were found		Bacilli identified	Class
Wied-il-Kbir	89	1 c.c.	eight times	Lactis aerogenes (4)	2
		5 c.c.	twenty times	Grunthal	3
		10 c.c.	nineteen times	No. 67	1
		20 c.c.	seventeen times	No. 109	?
		25 c.c.	ten times	Coscoroba	2
		50 c.c.	nine times		
		100 c.c.	six times		
Wied-Isseuda	98	1 c.c.	fifteen times	Grunthal	3
		5 c.c.	seventeen times	Coscoroba	2
		10 c.c.	eleven times	Cloacae	3
		20 c.c.	fourteen times	No. 109	?
		25 c.c.	sixteen times	No. 74	?
		50 c.c.	eighteen times	No. 8	?
		100 c.c.	seven times		
Wignacourt before treatment ...	51	0·5 c.c.	once	Lactis aerogenes	2
		1 c.c.	six times	Grunthal	3
		10 c.c.	twelve times	Acidi lactici	2
		5 c.c.	thirty-two times		
Santa Maria Tank	27	1 c.c.	twice	Grunthal	3
		5 c.c.	twenty-five times		
Smaller Tanks after treatment...	20	Absent in 100 c.c.			

TABLE II. Results of Chemical Examinations made between August 1911 and February 1912.

Name of supply	Parts per 100,000								
	Ammonia		Oxygen absorbed	Oxidised Nitrogen as N.	Chlorine as Cl.	As $CaCO_3$			Total solids
	Free	Albuminoid.				Total hardness	Permanent hardness	Temporary hardness	
Ta Baldu	0·0003	0.002	0.006	0.05	9.2	16.43	6.5	9.93	39
Hofriet-ir-Rizz ...	Nil	0.002	0.0006	0.05	8.0	14.84	6.0	8.84	39
Misrah-Suffara ...	0.0003	0.002	Nil	0.13	8.0	14.06	6.0	8.06	39
Bonua	Nil	0.001	Nil	0.06	8.8	14.06	5.8	8.26	39
Wied-il-Buzbiez ...	Nil	0.001	0.00018	0.12	7.4	14.06	5.8	8.26	32
Ta Cianti	Nil	0.001	0.00025	0.24	10.8	19.60	7.1	12.50	53
Ghain Kajjed ...	Nil	0.002	Nil	0.23	9.0	17.22	7.8	9.42	43
Ghain Klieb ...	0.0003	0.002	Nil	0.13	8.2	16.43	6.5	9.93	44
Tat-Targia	Nil	0.002	Nil	0.23	8.4	15.63	6.5	9.13	42
Buzigrilla	Nil	0.007	0.054	0.15	20.0	24.39	12.56	11.83	85
Gheriexem	Nil	0.007	0.060	0.45	35.0	47.02	25.35	21.67	180
Tal Ghemieri ...	0.0003	0.002	Nil	0.12	8.0	13.31	5.8	7.51	37
Tas-Senia	0.0003	0.002	0.007	0.05	8.0	16.43	6.5	9.93	47
Tas-Sala	Nil	0.002	Nil	0.03	8.0	14.06	5.8	8.26	27
Ta Rapa	Nil	0.002	0.004	0.05	8.6	15.63	6.5	9.13	33
Ghirghenti	Nil	0.002	0.0006	0.04	8.2	16.43	7.0	9.43	42
Mina Cbira... ...	Nil	0.002	0.002	0.10	8.4	18.04	7.8	10.24	42
Calcara	Nil	0.002	0.006	0.10	8.8	18.04	7.8	10.24	43
Tal Iskof	Nil	0.002	0.006	0.05	8.4	18.04	7.8	10.24	42
Lunziata	Nil	0.010	Nil	0.05	8.0	14.84	6.0	8.84	40
Fawwara	Nil	0.010	Nil	0.03	9.6	16.43	6.5	9.93	40
San Giorg	Nil	0.0005	0.001	0.012	8.6	14.84	6.0	8.84	35
Rabat	0.002	0.003	0.018	0.10	11.4	18.81	9.57	9.24	40
Bur-nuhhala ...	0.005	0.003	0.013	0.05	8.2	15.63	6.5	9.13	42
Tal Gnien	Nil	0.002	0.001	0.025	7.4	14.06	6.0	8.06	28
Armier	0.005	0.002	0.010	0.15	36.0	26.00	17.2	8.80	120
Wied-il-Kbir ...	Nil	0.001	0.0003	0.60	16.0	22.02	7.8	14.22	64
Wied-Isseuda ...	0.0005	0.002	0.0002	0.05	13.6	21.19	8.86	12.13	59
Wignacourt Total ...	0.0003	0.001	0.0006	0.23	8.1	15.63	6.50	9.13	33