December 2021

Effect of mechanical systems in combating the schistosomiasis snails

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EFFECT OF MECHANICAL SYSTEMS IN COMBATING THE SCHISTOSOMIASIS SNAILS

SHERINE AHMED EL BARADEI

2000

THE AMERICAN UNIVERSITY IN CAIRO

ENGINEERING DEPARTMENT

EFFECT OF MECHANICAL SYSTEMS IN COMBATING THE SCHISTOSOMIASIS SNAILS

BY

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B.Sc. Construction Engineering, AUC, 1997

A thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Engineering

with concentration in:

Environmental Engineering

under the supervision of:

Dr. Salah El - Haggar

Professor of Energy and Environment

January, 2000

The American University in Cairo
School of Sciences and Engineering

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A Thesis Submitted by

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DEDICATION

I would like to dedicate this thesis to my dear parents , since their encouragement , support and assistance helped me a lot in carrying out the work of this thesis.

ACKNOWLEDGMENT

I would like to express my appreciation to all personnel of the SBSP sector at the Theodor Bilharz Institute and particularly to Dr. Fouad Youssef, sector director, for his assistance in providing all the needed snails for carrying out the experiment.

I would also like to express my gratitude to the personnel of the WHO and particularly to Dr. El Khawashky for the assistance in using their library.

I would further like to express my thanks to Eng. Mahmoud Shafik, head of the malacology unit at the Ministry of Health and population for his assistance in providing informations about the snail control in Egypt.

I would also like to thank the personnel of the NAMERO especially Eng. Adel Zaki , Dr. Karim Kamal , Dr. Sami Faried , and Dr. Noshie Mansour for their assistance in providing informations about Schistosomiasis and for using their library.

My full gratitude to the biology department in the American University in Cairo, and especially Dr. Andrew Main and Mr. Osama Said Ali, the biology laboratory supervisor, for their help in using their lab.

I would also want to express my great thanks to the snail control laboratory and the workshop technicians especially Mr. Zakarya Taha , Mr. Hamdi Abdel Sattar and Mr. Saleh.

I would like very much to thank may parents fore their care and support.

I would further like to express my sincere thanks and deep respect to Dr. Salah El Haggar, Professor of Energy and Environment , AUC, for his constant support, help, guidance, and encouragement throughout the progress of this thesis work.

ABSTRACT

Schistosomiasis is a very serious disease in Egypt and most of the developing countries. It causes losses in lives of human beings; and if not dead the human being will turn out to be a sick person that has no energy and no capability of being productive. This will cause the country losses in man power and ; hence, economic losses. To solve this problem, many research institutes and world organizations are doing continuos studies aimed at eradication of the disease.

The disease has a life cycle in which the human being is the final host and the snail is the intermediate host. Controlling the disease could be carried out in two ways; curing the human being by medication, and controlling the existence of the snails. To serve the first purpose, medicines and vaccines are used, but it is better to control the disease before it reaches the human being. As a result, efforts were channeled towards combating the snails. There are three methods to control the snails, 1) the biological methods, 2) the chemical methods, and 3) the mechanical methods. The biological methods proved to be difficult to implement in the field; whereas, the chemical methods are very expensive and do harm to the environment and especially aquatic life. The mechanical methods, on the other hand, are easier to implement and are environmentally friendly.

The aim of this research is to control or prevent the existence of the snails with mechanical means. The thesis is concerned with examining the effects of the swirling or vortex motion on the percentage kill of the snails. To carry out this purpose, swirlers with different blade angles, configurations and sizes where used. Also a fine screen mechanical cleaning system was constructed for the purpose of retaining the baby snails. The two set ups (swirling flow generator and fine screen continuous cleaning system) are to be placed at the intersection of two canals in order to prevent the transmission of the snails from one canal to the other.

Experimental investigations were carried out to study the effect of swirling flow on the percentage kill of the snails (in this thesis baby snails were used because they are the hardest to combat since they are very small). To serve this purpose set-ups were constructed in order to carry out the needed experiments.

Swirlers of 10 cm diameter and with different blade angles of 15°, 30°, 45° and 60° were used in order to study the effect of the variation of blade angle on the snails' percentage kill. It was found that the highest percentage kill (92%) was associated with the 15° angle.

Different swirler' sizes were also investigated. It was observed that a 6 cm diameter swirler with 15 degrees swirl angle resulted in a higher percentage kill (98%) than the swirler with the 10 cm diameter.

Also different swirlers' configurations were examined. First single swirler of 10 cm diameter and 15° angle was tested; then a parallel swirlers' set-up of 15 cm outer diameter and 15° angle was tested. Results revealed that the parallel configuration was more effective in killing the snails and reached 94 percentage kill.

Also the effect of the volume flow rate of water was studied and it was found that decreasing the flow rate decreases the value of the percentage kill because the velocity decreased, which (velocity) was tolerated by the snails.

The effects of temperature (50°c) on the percentage kill of snails was studied and it was found to be 93% as compared with 92% in case of no heating (using 15 degrees and 10 cm diameter swirler).

As concerning the strain of the snails, the Bulinus snails yielded a percentage kill of 70% as opposed to the Biomphalaria snails which resulted in a 92 percentage kill at the 15 degrees swirler.

A second apparatus ,which is the fine screen mechanical cleaning set-up, was also constructed. This apparatus is meant to be installed at the exit of water from the swirling generators. This is to ensure that no snail will enter the desired canal because actually a double protection was done, namely the swirling generators plus the fine screening which will retain any baby snails.

Finally it could be concluded that decreasing the swirler angle will increase the percentage kill of snails. The parallel set-up results in a

higher percentage kill than the single one provided that the inner swirler in the parallel set-up will have the same diameter as the single swirler. Raising the temperature has minor effect on the percentage kill ; whereas, decreasing the swirl diameter will highly increase the percentage kill of snails. The justifications for each result will be discussed in the thesis. The swirling apparatus along with the fine screen mechanical cleaning set-up will ensure controlling the existence of snails.

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LIST OF ABBREVIATIONS

Biomp.	:	Biomphalaria alexandrina
S.	:	Schistosoma
g.c.	:	Gynecophoric canal
o.s.	:	Oral sucker
v.s.	:	Ventral sucker

Chapter (1)

INTRODUCTION AND BACKGROUND

1.1- Introduction

Schistosomiasis is one of the most serious and dangerous waterborne diseases -caused by flatworms- in the world. 200 million people over the whole world are infected with Schistosomiasis and 600 million are at risk. The disease is spread over more than 70 countries most of them are developing countries.[1]

Schistosomiasis or Bilharziasis as it is called after the scientist Theodor Bilharz is a very ancient disease . This disease appeared since the era of the Ancient Egyptians.[2]

Schistosomiasis is widespread in tropical areas and in areas where there are waterways such as lakes , rivers, and drains. Also it is found in areas where there are lots of irrigation practices especially those kinds of irrigation that would leave the land wetted for a long time such as the flood irrigation system seen in rice fields.

The disease has a life cycle in which the human being is the final host and the snail is the intermediate host. The life cycle in brief goes as follows; eggs that come from the secreta of man will be released into the water. After some period of time those eggs will hatch and produce meracidia that in turn will swim searching for the snails , and once they find their snail host they start penetrating it. The snail then -after some time- will shed cercariae and those will search for the final host which is

the human being. Once they find their host, they penetrate his skin and develop in his body to mature worms. Those worms after a while lay eggs that will be secreted out of the human body with the urine or stool. Then the cycle repeats itself again.

There are many types of schistosomes in the world. But as this study will be restricted to Egypt then focus will be given towards both types of schistosomes that are found in Egypt. Those types are, Schistosoma Haematobium, which is the urinary type of schistosome. The other type is Schistosoma Mansoni , which is the intestinal type of the disease.

Because of the losses in lives and the economic losses that are caused by the widespread of the Schistosomiasis disease, international organizations such as the World Bank and the WHO , as well as, local or national organizations such as the Public Health Ministry and the Institute of Theodor Bilharz make continuos efforts to fight and control the disease. There are two types of solutions to control the disease , either before the human being is infected or after the infection. To treat the disease after the infection occurs is through the usage of medicines - the so called parasequentials-. This is not a very good or effective solution of the problem because the medicine has undesirable side effects. Also another problem here is that people could be reinfected when they get in contact with contaminated waterways again. As a result it is better and more effective to try to control the disease before reaching the final host (human being) and infecting him. It was thought that perhaps a vaccine against the infection with Schistosomiasis is a good idea. This proved no

success up till now, as will be explained afterwards in the thesis,but still scientists are working on it.

The best known method, however, to control the disease is by controlling its intermediate host, namely the snails. By controlling or preventing, if possible, the growth of the snails , the life-cycle of the disease will be damaged and hence the disease could be eradicated.

Snail control happens through three control methods, the biological method, the chemical method, and the physical method. The biological method involves fighting the snails with their natural enemies such as ducks, fish, water bugs, another competitive snails, and crabs. The chemical method involves the usage of chemical compounds called molluscicides to kill the snails. The physical methods are divided into mechanical and irrigation controlling methods. The mechanical method includes designing devices that would lessen the number of snails without harming the environment and the aquatic life ; for example the designing of screens that would prevent the passage of snails through intakes to other areas. Some of the irrigation control methods are, to manipulate with the canal's slope designs so as to reach a high velocity in which the snails cannot survive. Other irrigation control methods are, to use palm leaves as traps for the snails, and to cover the irrigation ways so as to lessen the human contact with them as well as to prevent light from penetrating the water because snails cannot live in darkness. Another physical control method is to control the pH values of the water in such a way so that the snails cannot live in it.

The previously mentioned control methods in addition to other control methods will be studied in detail throughout this research in order

to be able to use some of them in coming up with a new mechanical method to control the snails. The thesis will focus on finding mechanical means to control the snails.

1.2- Background

Schistosomiasis is one of the most important health problems and is a very serious water-habitat disease facing Africa and much of the tropical world. Schistosomiasis is mostly widespread in areas where there are canals and in agricultural fields where flood irrigation is used [1]. The disease occurs in every country in Saharan Africa, the Middle East, East Asia, in Brazil and around the Caribbean. It does not occur in temperate climates, except for some places of Japan and China. Schistosomiasis is usually an endemic infection, but some times it can cause sudden epidemics and this is when abrupt environmental changes happen [2].

Schistosomiasis infects both males and females ; although , the side effects that happen to the female lead to more dangerous consequences than those which happen to the male. This is so because the female 's side effects harm them ; as well as , their children; whereas , the side effects of the man harm him only. Among the side effects of Schistosomiasis are : hematuria (blood in urine), weakness, cancer , and abdominal pain. For the women hematuria will let them loose hemoglobin and very important metals which in turn , if the woman is pregnant, will badly affect the embryo and results in having an ill and

weak child. So the effects of the infection of a female with Schistosomiasis persists till future generations as well.

1.2.1-Types of Schistosomiasis and their geographic distribution

The disease is caused by several trematodes (flatworms) of the kind Schistosoma. ***S. Haematobium***, the agent of urinary Schistosomiasis, is confined to Africa and the Near Middle East and the Middle East [3]. ***S. Mansoni***, which causes the intestinal form of the disease, is found in Africa, Saudi Arabia, Yemen, South America, and the Caribbean. In those parts of Africa where both S.Haematobium and S.Mansoni are prevalent mixed infections are not rare [3]. ***S.intercalatum***, which also causes intestinal disease, is found in man only in limited foci in West and Central Africa : Zaire, Congo, Central African Republic, Gabon, Cameroon and Nigeria. ***S. japonicum***, is confined to the far East [3]. (Fig.1)

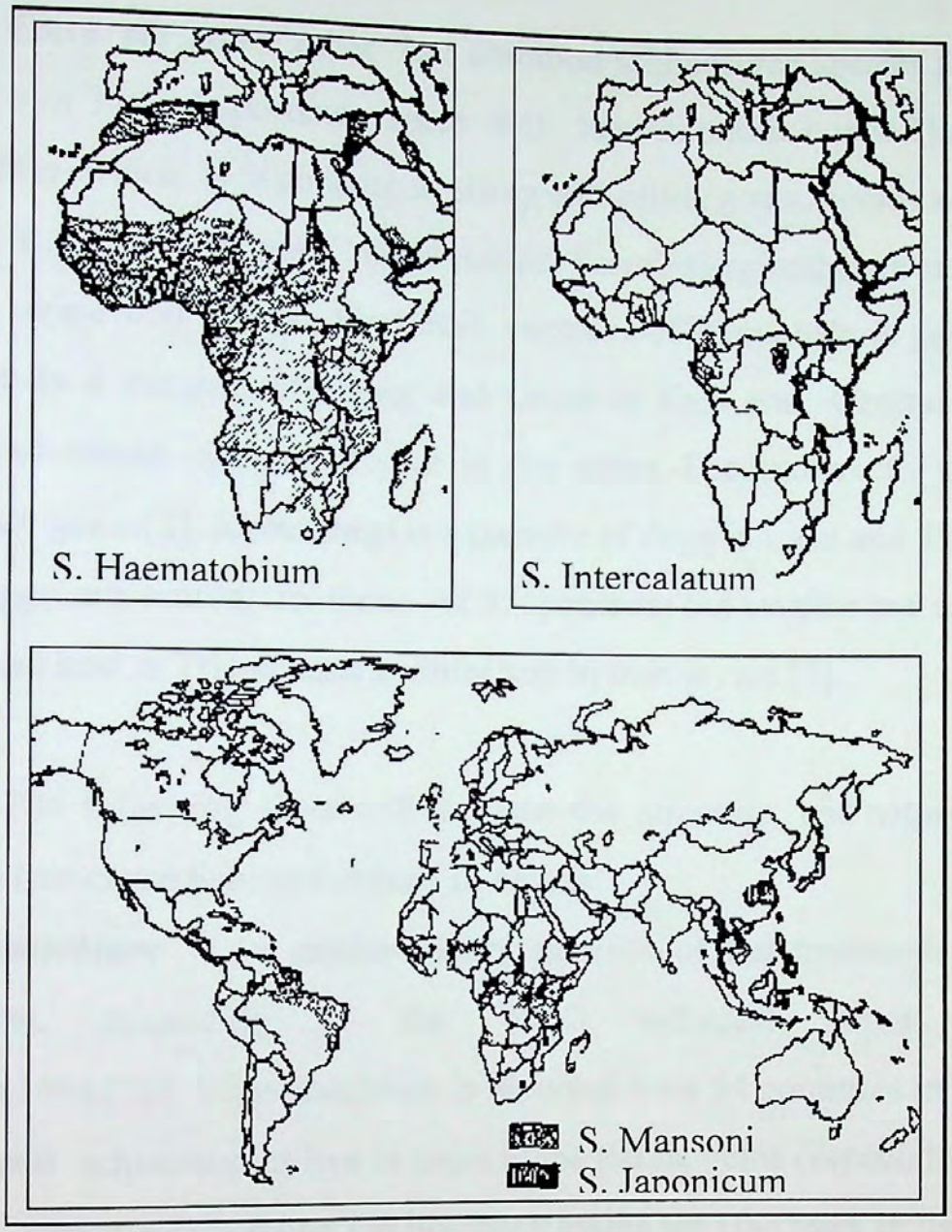


Fig. 1 : Geographical distribution of Schistosomiasis [2].

There are some other less common schistosome species found in man, with little importance since they have zoonotic hosts. These are: ***S.matthei*** which is a parasite of sheep and cattle, goats, horses and wild game in South-East and Central Africa. Terminal-spined eggs are found in the urine and stools. The snail vector is of Biomphalaria genus [3]. ***S.bovis*** is a parasite of sheep and cattle in East and Central Africa. Terminal-spined eggs are found in the urine. The snail vector is of the Bulinus genus[3]. ***S. mekongi*** is a parasite of dogs in Laos and Thailand. The eggs are similar to those of S.japonicum but smaller and rounder. The snail host is Tricula aperto. Infection in man is rare [3].

The following lines will explain the structure and nature of the worms that cause Schistosomiasis in details:

S.haematobium is a genito-urinary parasite of the trematoda order; Strigeata. According to the WHO technical report series, no.830,1994,[15] S.haematobium is reported from 54 countries in Africa. The adult schistosomes live in pairs in the pelvic veins (especially in the venous plexus surrounding the bladder); males are 10-15mm in length by 0.8-1mm in diameter, and have a ventral infolding from the ventral sucker to the posterior end forming the gynecophoric canal. Females are slender (0.25mm in diameter) and longer (up to 20 mm in length), and are held in the gynecophoric canal during copulation (Fig.2). Each female lays about 150 eggs per day. The diagnosis of urinary Schistosomiasis requires the identification of eggs in urinary sediment. Eggs measure 115-185 by 40-70 μm and have a terminal spine (Fig.3) ; viable eggs contain a motile miracidium. S.haematobium eggs can occasionally be found in feces. Eggs are the main agent of pathology including granuloma formation.[4]

S.mansoni, is an intestinal (helminths) and liver parasite of termatoda order; Strigeata. According to the WHO technical report series, no.830,1993, S.mansoni is endemic in 43 countries in Africa and occurs in the Americas in Brazil, Suriname, Venezuela and in the Caribbean. Adult schistosomes live in pairs in the portal system and in the mesenteric venules; males are shorter (7-12mm in length and 2mm wide) and have a ventral infolding from the ventral sucker to the posterior end forming the gynecophoric canal. Females are slender (1mm in diameter) and longer (9-17mm in length), and are held in the gynecophoric canal during copulation (Fig.4). Each female lays about 300 eggs per day. S.mansoni eggs measure 110-175 by 45-70 μm; the color is yellow, with a thin transparent shell and a strong lateral spine (Fig.5).Viable eggs contain the motile larva, the miracidium. After breaking the shell the ciliated miracidium moves in the water and reaches the mollusca. Diagnostic methods include intestinal or liver biopsy and looking for eggs in the feces [4].

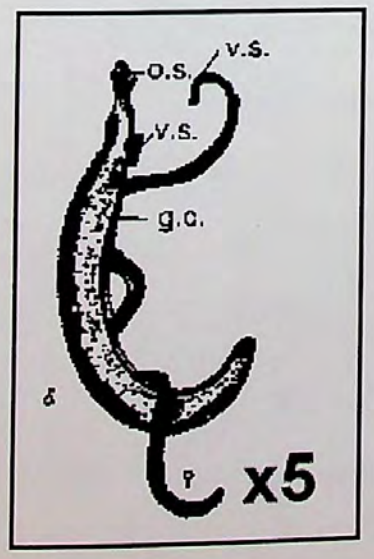


Fig. 2 : S.Haematobium worm[4]

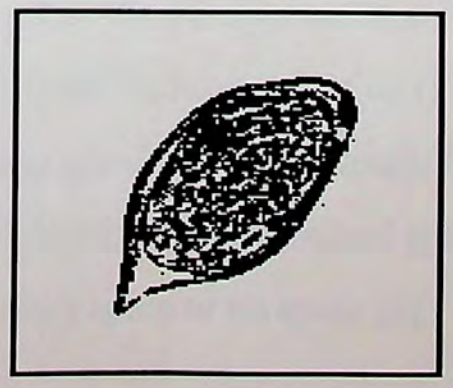


Fig. 3 : S.Haematobium ovum[4]

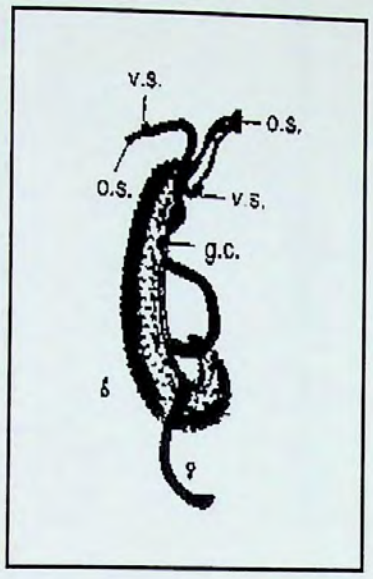


Fig. 4 : S.Mansoni worm [4]

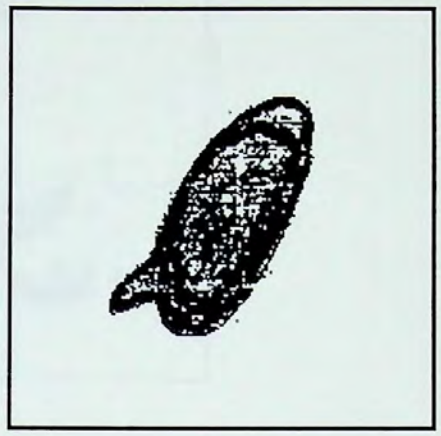


Fig. 5 : S.Mansoni ovum[4]

S.japonicum, is an intestinal and liver parasite of the of trematoda order; Strigeata. According to the WHO technical report series, no.830,1993, S.japonicum occurs in Southeast Asia and western Pacific countries including China, the Philippines and Indonesia. Adult schistosomes live in pairs in the portal system and in mesenteric venules; adults of S.japonicum are bigger than adults of S.mansoni. Males are 12-20mm in length and 0.5 mm wide, and have a ventral infolding from the ventral sucker to the posterior end forming the gynecophoric canal. Females are slender (0.3mm in diameter) and longer (up to 26mm in length), and are held in the gynecophoric canal during copulation (Fig. 6). Each female may lay up to 2000-3000 eggs per day. Eggs measure 70-90 μm in diameter, are oval to round in shape with subterminal spine (Fig.7). Eggs are usually round and have a small spine or no spine.[4]

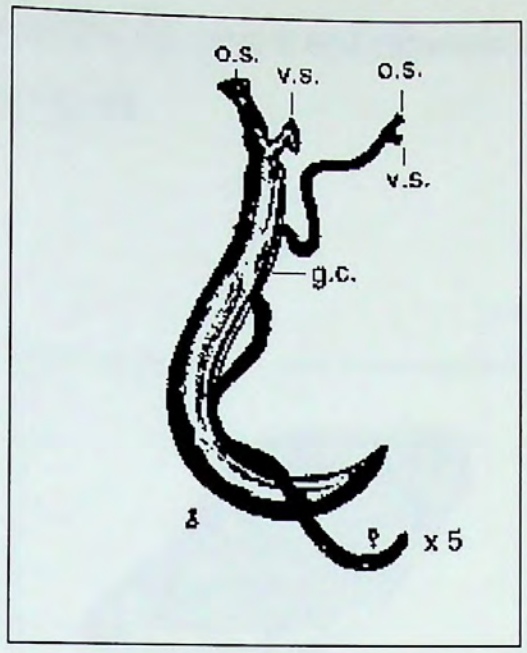


Fig. 6 : S.Japonicum worm[4]

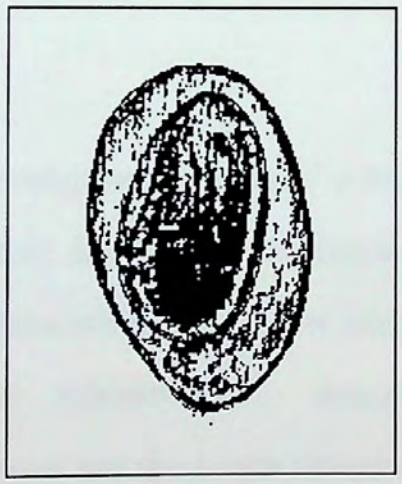


Fig. 7 : S.Japonicum ovum[4]

S.intercalatum, is an intestinal parasite of the trematoda order; Strigeata. According to the WHO technical report [15] S.intercalatum has been reported from Central and West Africa. Adult schistosomes live in mesenteric venules; males are shorter and have a ventral infolding from the ventral sucker to the posterior end forming the gynecophoric canal. Females are slender and longer, and are held in the gynecophoric canal during copulation. Diagnosis is achieved by fecal examination and rectal

biopsies. Eggs are rhomboid in shape and measure 250 μm and have a long terminal spine.[4] (Fig. 8).

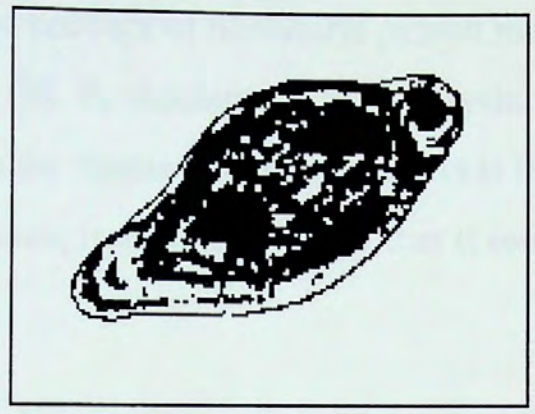


Fig. 8 : S.Intercalatum ovum [4]

The four previously mentioned types of schistosomes are the most widespread types. The other kinds of schistosomes like S.mekongi , S.bovis and S.matthei are less widespread. The research thesis will focus only on two kinds of schistosomes, namely ***S.mansoni*** and ***S.haematobium***, because those are the kinds found in Egypt.

1.2.2-Historical background

1.2.2.1- Schistosomiasis in ancient Egypt

The ancient Egyptians, through settling and cultivating the Nile Valley, were among the first to contact the disease in an endemic manner [5]. They recognized the disease about five thousand years ago and mentioned it in medical papyri as well as on the walls of temples[6].

Recently, this was confirmed by direct demonstration of the eggs of the parasite in the tissues of mummies through paleopathologic studies [7,8].

The disease was first mentioned in the papyrus of Kahun (1900 B.C.). It was named "a-a-a" disease (Fig. 9). The phallus was used as a symbol to represent the concept of hematuria ,which means the existence of blood in the urine [9]. To Ancient Egyptian physicians, the symptom itself was regarded as the disease. Since hematuria is the basic symptom of urinary Schistosomiasis, it may be assumed that it refers to this disease [5].

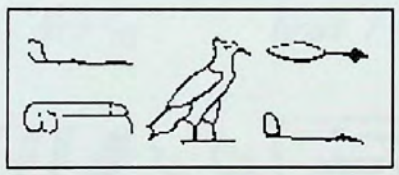


Fig. 9 : Hematuria as recorded in the Kahun papyrus[6]

A casual relationship to a verminous parasite is reported in Ebers Papyrus (1550 B.C.), prescription 62 [10,11], of which a reproduction of its hieroglyphic script, and English translation are shown in figure (10). As it reads, it characterizes the disease (hematuria), causative parasite, some herb therapy and a comment on its intractability ; "they are not killed by any remedy" (Fig. 10). It is interesting that the Ancient Egyptian in antiquity knew the same facts that we know now at present. [5].

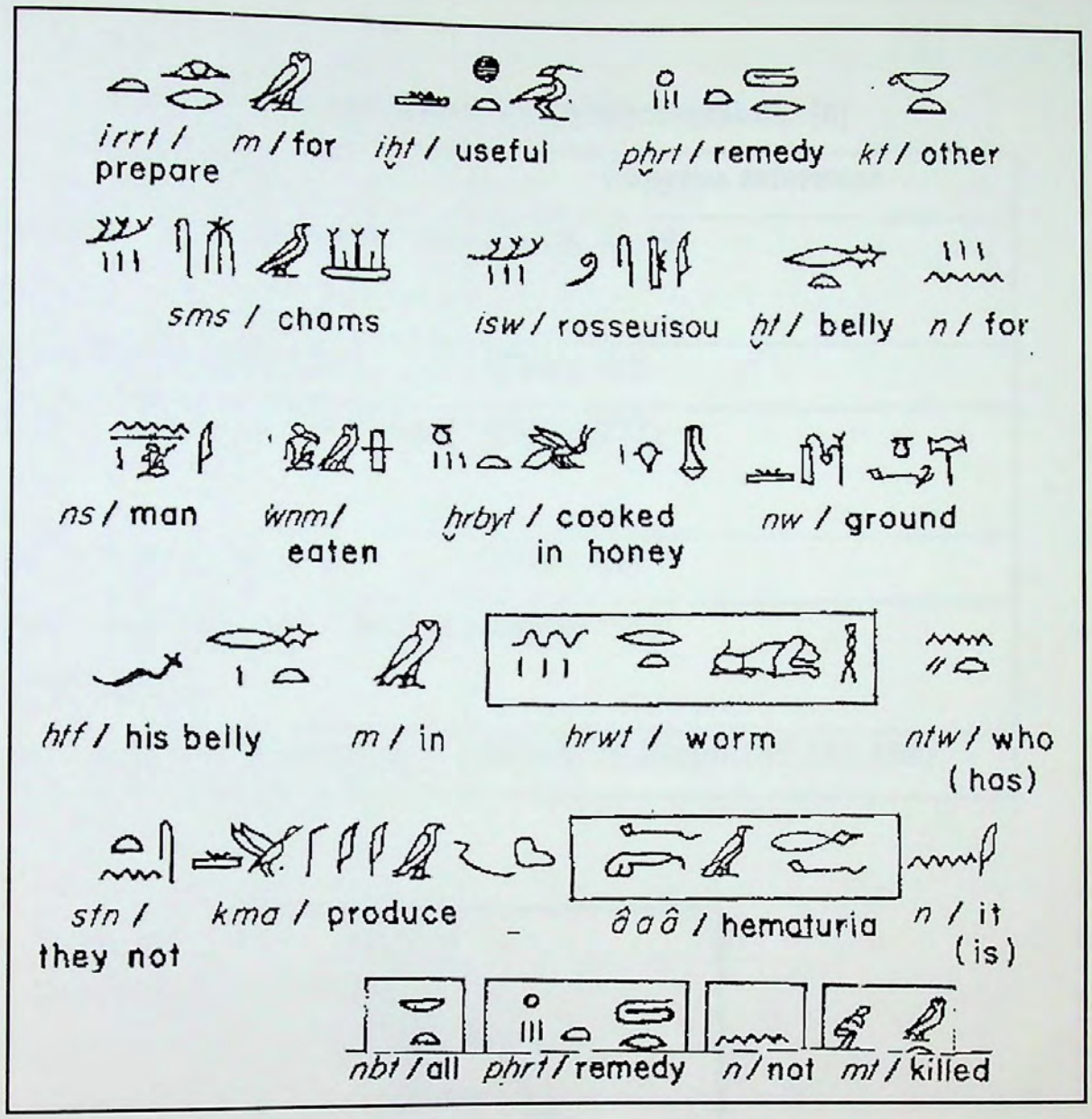


Fig. 10 : The Ebers papyrus [10]

The clinical symptoms of the disease as described in medical papyrus are present in Table 1.1. These symptoms represent both urinary and intestinal Bilharziasis.

Table 1.1 : Clinical features of Schistosomiasis [6]

Symptoms	Papyrus reference
1.Hematuria and frequency of micturition	(Ebers: 46,49)
2.Referred pain to hinder part	(Ebers: 42)
3.Cardiac disturbance and mental weakness	(Ebers: 227)
4.Abdominal pain (Fig. 11)	(Ebers: 62)
5.Painful micturition and affection of anus and rectum	(Ebers: 138)
6.Diarrhea and sanguinous stools	(Ebers: 19,Berlin:165,187,188)

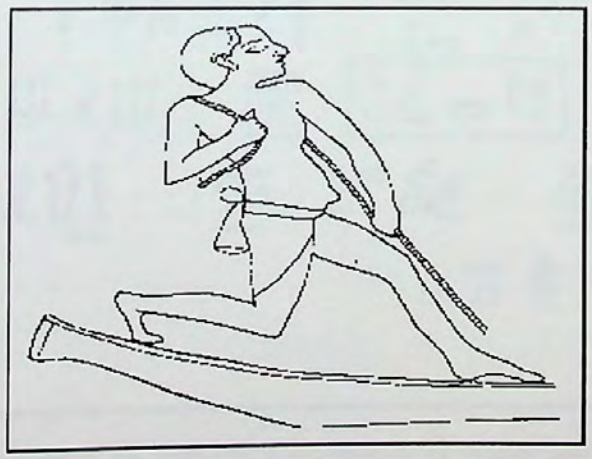


Fig. 11 : Abdominal distention & umbilical hernia in a boatman, Path-Hetep's tomb, Saqqara.[6]

In Ancient Egypt , there was a general belief that all sickness and disease came from without and were mainly due to the action of evil spirits. Hence medicine at that time was essentially a mixture of religion and magic [12,13]. However, a beginning of a scientific treatment such

as surgical procedures and administration of drugs was documented in medical papyri. Ancient Egyptians described a variety of drugs for the treatment of Schistosomiasis (Table 1.2). These included palliative drugs such as sedatives, antispasmodics, narcotics and colonic evacuants. However, the use of a specific drug, namely: antimony (Fig. 12) , which is among the nowadays therapies of Bilharziasis, is really spectacular [5]. They also made a pioneer step in the prevention of this disease by discouraging people to get in contact with polluted waters.

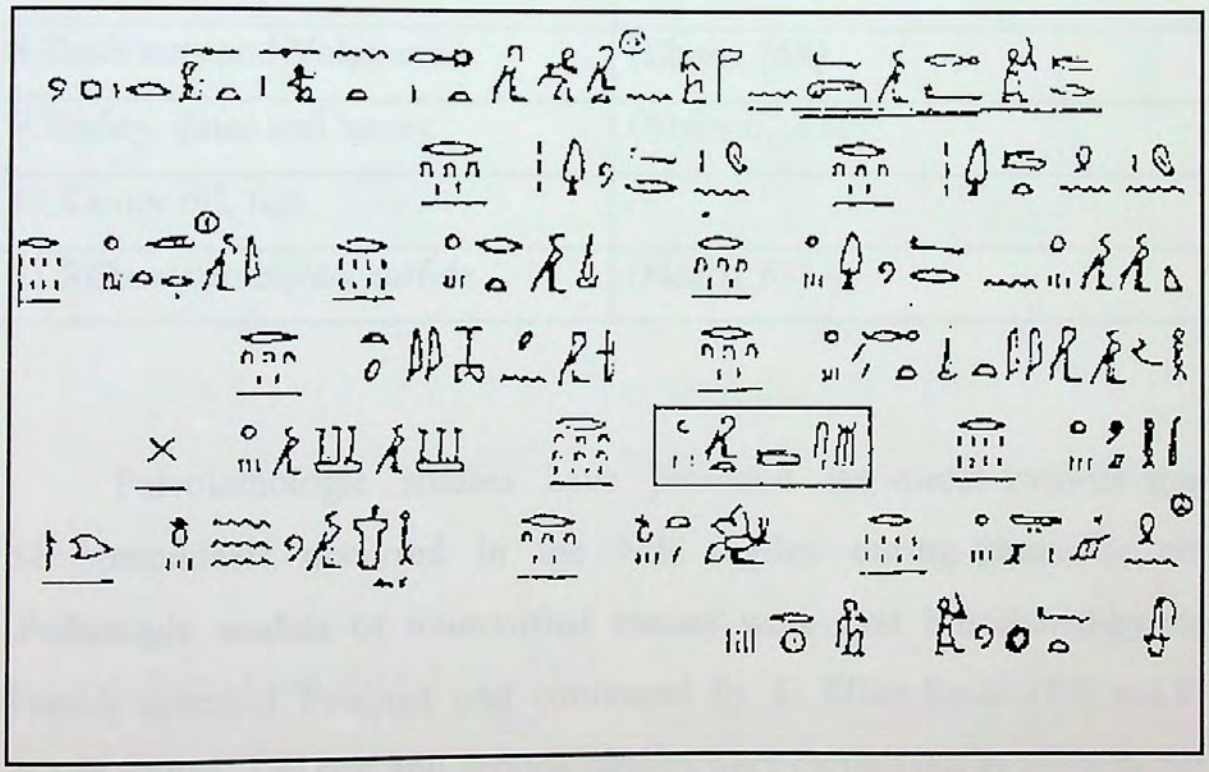


Fig. 12 : Hearst papyrus, in which antimony is mentioned [6]

Table 1.2 : Treatment of Schistosomiasis [6]

Drug	Papyrus reference
1.Ammi-visnaga & hyocyamus	(Ebers:173,230,331 Berlin:115)
2.Junipar and beer	(Ebers: 137)
3.Pomegranate roots in beer	(Ebers: 63)
4.Natron: sodium mono-and bicarbonate	(Ebers: 171)
5.Hemp	(Ebers: 59)
6.Dried crab	(Ebers: 226,228)
7.Balanites	(Ebers: 229)
8.Rush nuts and Valeriana	(Ebers: 168)
9.Barley, dates and honey	(Ebers:62,63)
10.Castor oil, figs	
11.Stibum: antimony sulfide	(Hearst:83)

Paleolathologic studies have provided the direct evident that Schistosomiasis occurred in the Nile Valley during pharaonic era .Pathologic studies of mummified tissues were first introduced by the French scientist Fouquet and continued by G. Elliot Smith [14] and F. Wook Jones. The real and serious studies were carried out in 1910 by Sir A. Ruffer [7,8]. It included for the first time the results of histologic examination of mummified tissues, rendered swollen to their former size and flexibility. Of the histopathologic findings, he reported on the presence of calcified S.haematobium eggs among the convoluted tubules of the kidneys of two mummies from the 20th Dynasty (1250-1000 B.C.).(Fig. 13)

Fig. 13 : Egg of S. Haematobium found in the colon of a mummy of a teenage Egyptian boy who lived in Thebes around 1200B.C.[7]

1.2.2.2- Schistosomiasis nowadays

Schistosomiasis were not discovered until after European scientists began to venture into the tropics. S.haematobium, the agent of urinary or vesicular Schistosomiasis, was first discovered by a German physician-pathologist, T.Billharz working in Cairo in 1851.[2] The disease is some times called Bilharziasis in his honor. He was first to demonstrate that the worms in the veins were responsible for haematuria so commonly observed in human beings who passed eggs in their urine. F.Katsurada, a

Japanese investigator described S.japonicum in 1904 . In 1913, N.Miyairi and N.Suzuki worked out the life cycle of S.japonicum, which involved snails of the genus Oncomelania. A British scientist , R.T.Leiper , visited Japan in 1914 and consulted investigators there. Following their lead, he investigated snails in Egypt, and in 1915 showed that Bulinus snails were the intermediate hosts of S.haematobium he also discovered and described the life cycle of it [2]. Meanwhile, many observers had noted the terminal-spined eggs were usually in the urine (S.haematobium) and the lateral-spined eggs were almost always found in the feces (S.mansoni) [2]. In 1907, using this and other information, Sambon described S.mansoni as a separate species. Various species of the genus Bulinus serve as vectors of S.haematobium; the snail hosts of S.mansoni are in the genus Biomphalaria. S.intercalatum was apparently observed in the Belgian Congo on several occasions prior to its formal description by Fisher in 1934.[2] Knowledge of the distribution and impact of the disease has grown slowly in most of Africa, as it did not occur in dramatic epidemics and, except in the Nile Valley, seemed for many years to have little economic impact [2].

The origins of Schistosomiasis are unclear, but several members of the genus Schistosomia infect wild and domestic mammals. Adamson, noting that both S.mansoni and S.haematobium can infect monkeys and baboons, has postulated that these parasites evolved as zoonoses (parasite that infects animals) in Central Africa and gradually became adapted to man. He argues that the disease reached Egypt via trade routes by the 12th century BC or earlier, and then spread into Middle East.[2]. If this is the case then, S.mansoni was obviously introduced into the

Caribbean and Brazil by the African slave trade of the 16^{th}-19^{th} centuries.[2]

1.2.2.3- Statistics of the infected people with Schistosomiasis

Schistosomiasis is the second most important tropical parasitic disease of man after Malaria. Although the disease is preventable and curable, the cost of control remains high. "Progress has been hindered both by economic constraints and by environmental changes associated with migration and water resources development, which have created new foci of transmission "[15].

However, with the recent concentrated efforts of the government along with changing social behavior, Bilharzia seems to be decreased in Egypt. A sample of 16,295 persons was selected and tested for Bilharzia or Schistosoma sample from Aswan, Kom Imbo, Beni Suef, and Kafr El-Sheikh. In addition, a sample of 6,024 persons was selected from Quena. The results of the examination of urine and stool of sample members for Schistosomiasis are shown in tables 1.3 and 1.4. The obtained results can be summarized as follows [1]:

1-The disease rates tend to decrease from north to south.

2-The peak infection is usually in the young adolescent age group 15 to 19 years of age.

3-For any specific age group the prevalence is higher in males than females.

4-Contrary to original speculations there is a general declining trend in the prevalence of Schistosomiasis in rural Egypt which has not been reversed by the construction of the Aswan High Dam. This may be primarily due to:

a-Effect of programs in environmental health including protected water supplies and concentration of latrines in villages.

b-Improved services by treatment of cases and health education.

c-Snail control programs.

d-Population shift from rural to urban areas.

The following tables give the rates of infection with Schistosomiasis at different governorates in Egypt.

Table 1.3 : Percent prevalence of Schistosomiasis by year and selected studies [1]:

	Percent Prevalence		
Governorate Source Year	**S. Haematobium**	**S.Mansoni**	**Schistosomiasis**
Kafr El-Sheikh (North Central)			
1937 Scott	53 (28-64)	51 (37-70)	83
1955 EMH	51	17	
1976 Current study	30 (11-53)	20 (14-28)	42
Qalyubia (South Central)			
1973 Scott	62 (33-85)	26 (1-49)	60
1952 Weir,et.al.	38 (31-53)	13	
1955 EMH	31	3	
1976 Alamy&Cline	27	41	
Beheira (North Western)			
1937 Scott	53 (36-79)	54 (43-72)	83
1955 EMH	46	31	
1966 Farouk,et.al.	30 (11-51)	29 (6-65)	41
1972 Gilles,et.al.	23 (0-62)		

Table 1.4 : Overall percent prevalence in the three different study areas[1]

Study Area	Percent Prevalence			
	S.Haema-tobium	**S.Mansoni**	**Dual Infection**	**Schisto-somiasis**
Nile Delta, Kafr El-Seikh	30 (11-53)	20 (14-29)	8	42 (22-67)
Upper-Middle Egypt,Beni Suef	27 (17-37)	---	---	27 (17-37)
Upper Egypt Aswan desert villages	4 (1-7)	---	---	4 (1-7)
Agricultural villages	25	---	---	25
Kom Imbo (New Nubia)	9	---	---	9

-The lowest and highest prevalence figures recorded in the area are given between parentheses and the free standing number is the weighted average.

1.2.2.4-The life cycle of Schistosomiasis

Schistosomes have complex life cycles involving man as the definitive host (where sexual reproduction occurs) and certain species of fresh water snails as intermediate hosts [2]. Adult worms live in male-female pairs in blood vessels (the female lives in the gynaecophoric canal of the male) (Fig 14) , where they may survive and produce eggs. S.haematobium usually inhabits small veins around the urinary bladder; S.mansoni generally lives in venules around the large intestine. Eggs pass through the bladder or intestinal wall and are voided with the urine or feces. Because of the preferred location of the adults, the characteristic

terminal-spined ova of S.haematobium are usually passed in the urine, while the lateral-spined eggs of S.mansoni almost always reach the outside world in the feces. If the eggs are deposited in fresh water they hatch into an embryo form, the miracidium (Fig. 15), which search for and penetrate into the proper snail hosts. If not finding a snail within 24 hours , the miracidium dies. The miracidium know their intermediate host by some fatty acids that are secreted from that host or snail. S.haematobium develops in Bulinus Trancatus and other species of bulinids; S.mansoni requires Biomphalaria snails. The penetration of the meracidium to the snail happens either through its head or through its tail. Those miracidia which become established in a suitable snail give rise by asexual reproduction to two generations of sporocysts and then, after about 4 weeks, the daughter sporocysts begin to produce large numbers of cercariae (Fig. 16) (it is estimated that if only one meracidium would penetrate a snail then this snail could release up to 100 thousand cercariae). Those leave the snail and swim with the aim of finding a new host [2] . If the final host is not found in 48 hours ,the cercariae die. Those which contact humans penetrate their skin leaving their tales outside, transform into a schistosomule stage, enter the capillaries, are swept to the heart, pass through the lungs, and enter the systemic circulation. Those which reach the liver develop further for about three weeks, and then migrate against the flow of blood to the small veins where they reside, with the female living in a groove in the body of the male. Copulation takes place and eggs can be produced within 7-12 weeks of initial infection [2]. Then the life cycle repeats itself again. (Fig.17 and Fig 18)

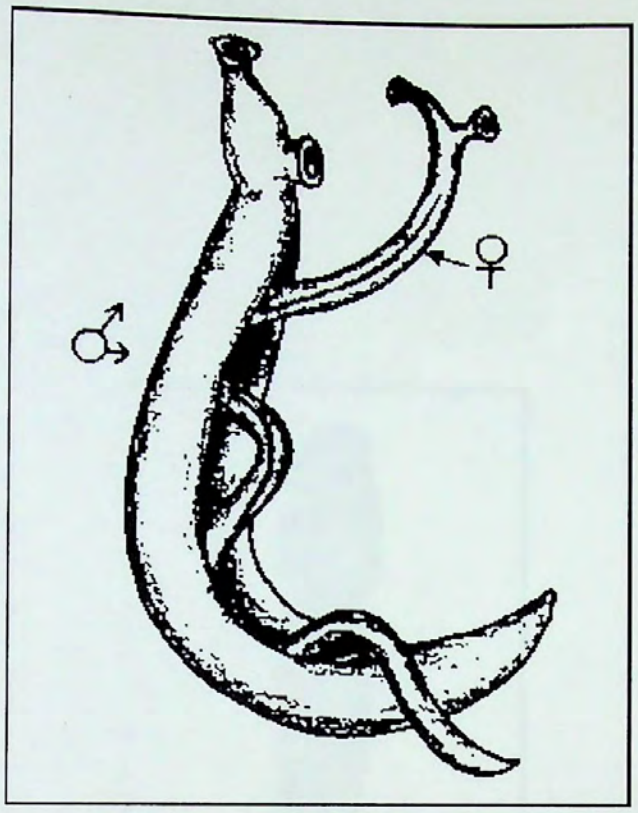


Fig. 14 : Male and female schistosomes [15]

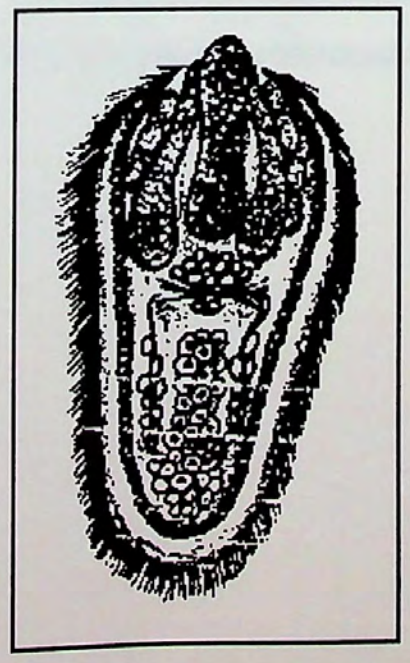


Fig. 15 : Schistosoma meracidium [15]

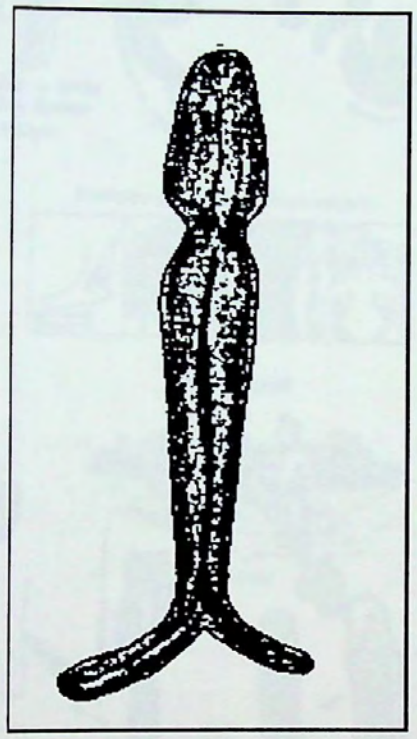


Fig. 16: Cercarie of schistosoma [15]

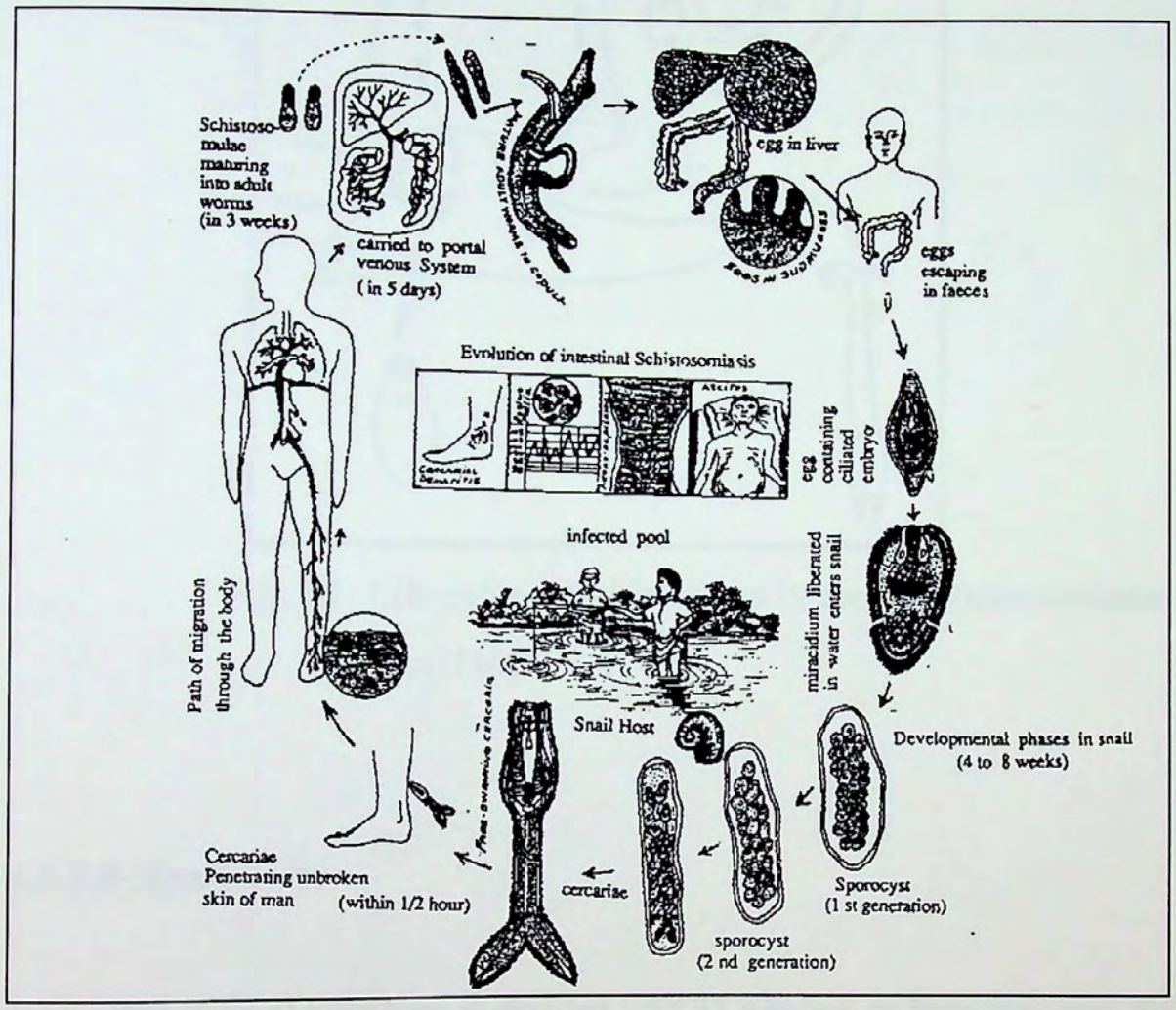


Fig. 17 : Life cycle of S.mansoni [15]

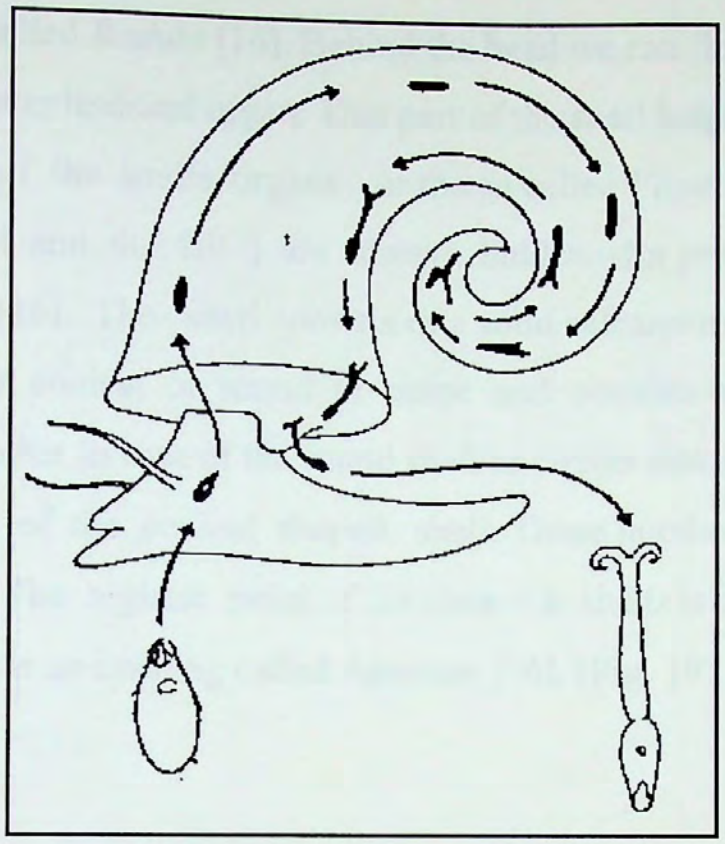


Fig. 18 : Life cycle of schistosoma in the snail(intermediate host) [16]

1.2.2.5- Snail hosts

The animal kingdom is divided into 31 *phylum* or branches and the snail is under one of those 31 phylum which is called Mollusca (which means gelatinous). The phylum of Mollusca is divided into 6 classes which are in turn divided into subclasses [16]. There are different types of snails, namely, earth snails, saline-water snails and fresh-water snails. The last type of snails is the important one for this study because it contains the snails that are the intermediate host of the schistosomes [16].

The body of the snail consists of a head that has two pairs of sensory horns, a triangular shaped mouth which contains the tongue and

many teeth called *Radula* [16]. Behind the head we can find the tail; it is a muscular flat cylindrical organ. This part of the snail helps it to move or crawl. Most of the snails organs or the so called *Visceral hump*(other than the head and the tail) are always hidden -for protection- in the snail's shell [16]. The shell consists of a solid calcareous material. The shell is either conical or round in shape and consists of many circles within each other in case of the round shell or circles that are above each other in case of the conical shaped shell. Those number of circles are called *Spire*. The highest point of the cone -i.e. shell- is called *Apex*. In the shell there is an opening called Aperture [16]. (Fig. 19).

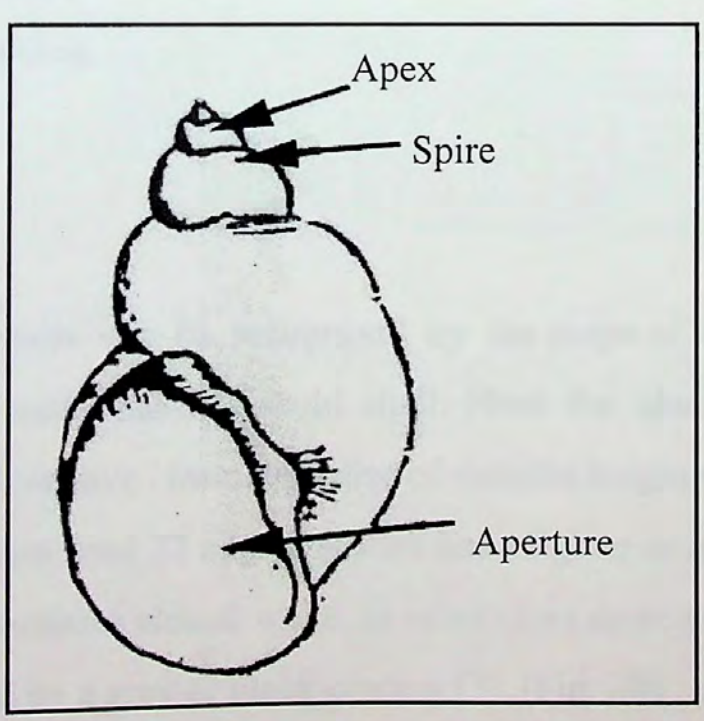


Fig. 19 : Structure of the snail's shell [16]

The different types of schistosomes are associated with different types of snails as their intermediate hosts. The snail intermediate host of

S. Haematobium are of the *Bulinus genus (Bulinus Trancatus)*; of *S. Mansoni*, the *Biomphalaria genus (Biomphalaria Alexandrina)*; and of *S. japonicum*, the *Oncomelania* . The following serves as an example for the scientific division of the Bulinus species as mentioned in the above paragraph :

Bulinus Trancatus [16]

Species: Trancatus

Genus : Bulinus

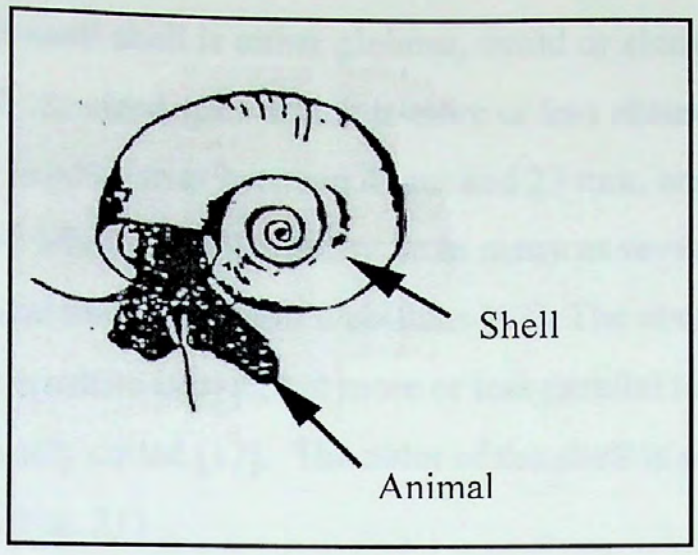
Family : Planorbidae

Order : Pulmonata

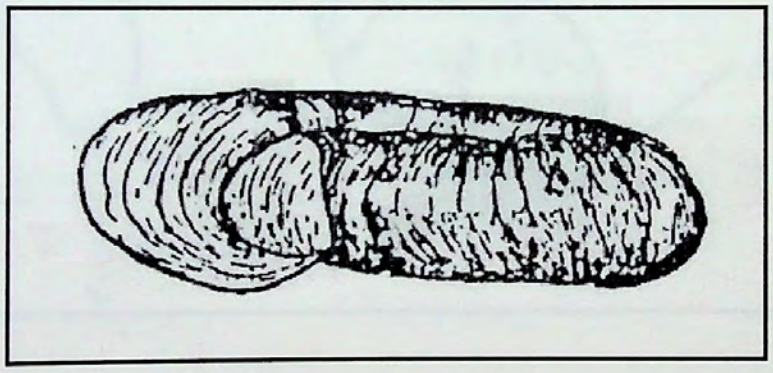
Class: Gastropoda

Subclass : Mollusca.

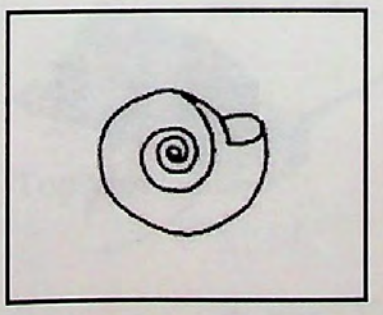
Those snails can be recognized by the shape of their shells. The Biomphalaria snails has a discoid shell. Here the shell is being ultra-dextral and biconcave forming a disc of variable height with a diameter of between 7mm and 22 mm. The shell has a lighter or darker brownish horn color, sometimes almost white, in other cases more reddish and very often concealed by a gray or black coating [3]. (Fig. 20)



A) Snail (shell with animal)



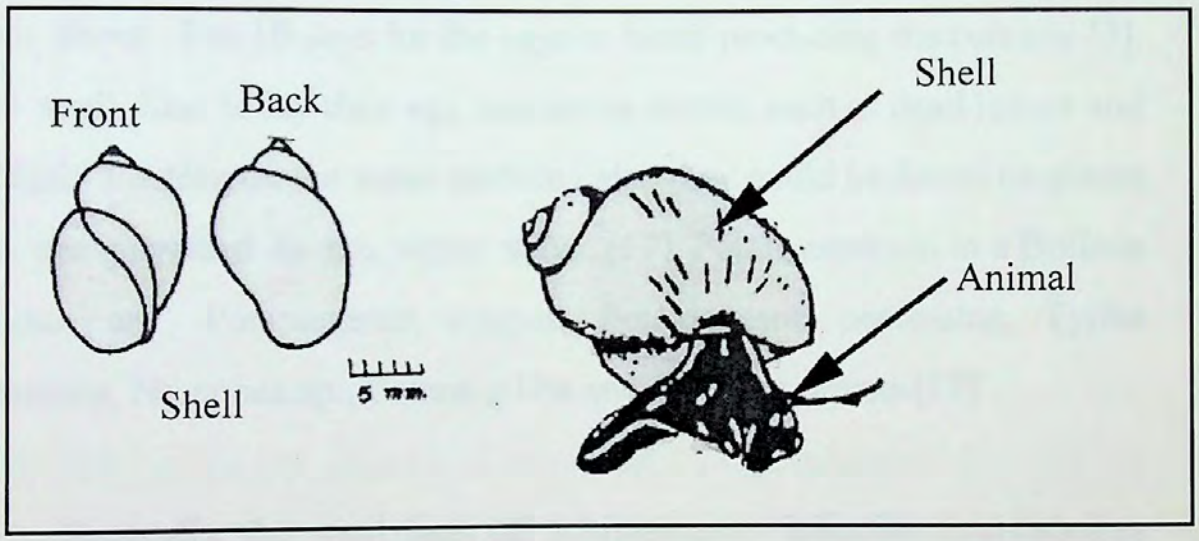
B) Front of the shell



C) Top view of the shell

Fig. 20 : Biomphalaria Alexandrina snails [16]

The Bulinus snail shell is either globose, ovoid or elongate with a short, long or medium-sized spire which is more or less obtuse at the summit [17]. The height varies between 4 mm and 23 mm, and there are usually four or five whorls, but there may be as many as seven [3]. The sutures are deep, and there is a slight umbilicus [17]. The apex of the shell is blunt. The aperture is oval, but more or less parallel to the shell's axis. All are sinistrally coiled [17]. The color of the shell is a lighter or darker brown [3] .(Fig. 21)



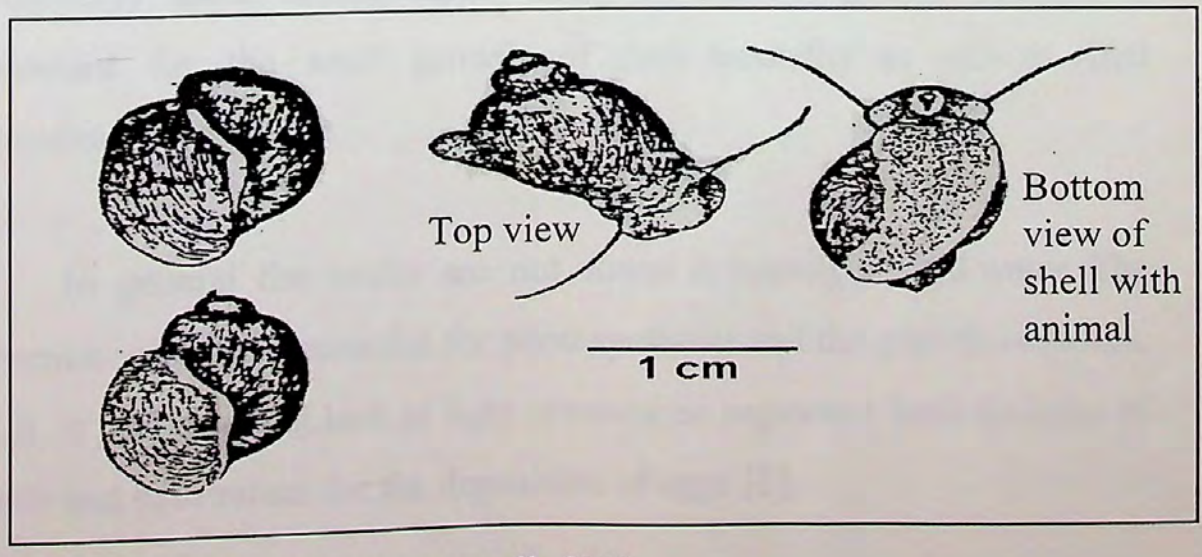


Fig. 21 : Bulinus Trancatus snails [16]

The snails are bisexual so they can produce eggs without mating with other eggs. Sometimes; however, the snail behave as unisexual [16]. It is observed that the snails that behave as bisexual lay more eggs than those that behave unisexual. The freshly laid eggs appear as a yellowish transparent gelatinous mass, oval or circular in shape. The egg masses vary in size, 5-10 mm in diameter, and main contain 6-28 egg [18]. The average rate of laying eggs is one egg mass / 4 days. The best temperature for the eggs is between 14C and 26C [16]. These can be carried on the feet of water birds and infect other bodies of water. It takes from about 7 to 10 days for the eggs to hatch producing the cercarie [3]. The snail like to lay their egg masses on debris, such as dead leaves and rubbish floating on the water surface , also they could be found on plants that are provided in the water ways [17]. Plants common in a Bulinus habitat are Potamogeton crispus, Potamogeton pectinatus, Typha angustata, Nymphea sp., Lemna gibba and Panicum repens [17] .

Generally the snail host of schistosomes infecting man requires fresh water. It was found out that the Biomphalaria genus could live in a (relatively) more saline water than the Bulinus genus. Calcium is important for the snail growth of shell fecundity as well as shell formation.

In general the snails are not found in heavily shaded water. The presence of light is essential for photosynthesis and the growth of plants, so it is probable that lack of light removes an important food resource of snails and substratum for the deposition of eggs [3].

Slow-flowing water is preferred by snails. For Biomphalaria and Bulinus snails the upper limits of tolerance of flow is about 0.3 m/s. These places are the center of intense transmission [3].

A Snail usually lives an average of approximately 1.5 to 2 years. The death rate of the snails increases in its first month -after the snail is born- and decreases at the 8th month then it increases again [16].

1.2.2.6-The spreading patterns of the snails

Talking about snails, it is worth to mention the spreading patterns of them. Results showed that the spreading patterns of snails along canals are changeable because of water current and irrigation activities. The snail population density showed two peaks, different in height, in April-May and November-December separated by two bottoms following the "Winter Closure" and during the hot summer season. The height of the peaks appears to be dependent on the extent of the "Winter Closure" and the prevailing water temperature [19]. It was noticed that the majority of snails live in waters with a temperature between 22-29° C. The large numbers of snails were collected from waters of pH 6.3 to 6.7 , even though snails may occur in waters of pH-values out of this range [20]. Also snails like to live in habitats where light is provided.-but not very sunny habitats-.

Snails prefer to live on the waterway slope because there the velocity is low (optimum velocity for snails is 0.3m/s). Also snails choose plants that are in the waterways as one of their habitats; this is

because of many reasons [16]; 1) Here the velocity is low. 2) The plants serve as a natural protection for the snails from their enemies, this is because the snails could not be seen while they are hidden in the plants. 3) Plants serve as a source of food for the snails. 4) Plants provide water with the oxygen needed by the snails. 5) The plants help in hindering the molluscesides from further spreading in the canals. 6) In the hot summer seasons , the plants provide the snails with adequate shading [16].

As mentioned before , this research thesis will focus on two types of schistosomes and hence two types of snails ,namely S.hematobium with its intermediate host as the Bulinus snails and S.mansoni with its Biomphalaria type snail host. So it would be important to mention where those types of snails could be found in Egypt. Biomphalaria snails are found in north Egypt i.e. in the governorates that are near Alexandria. Bulinus snails; on the other hand, exist more in South Egypt, i.e. Upper Egypt governorates. This distribution was before the construction of the High Dam. Before the construction of the dam, floods flushed and wiped out the snails of the ginus Biomphalaria to the north because of that those types of snails are more in Northern Egypt. After the construction of the dam, the water is regulated and no flood occurs that would flush the Biomphalaria snails in its way, that is why this type of snails is now started to be seen in the South of Egypt

1.2.2.7- Control of Schistosomiasis (snail control)

The epidemology of Schistosomiasis is obviously related to sanitation and water contact. As one modern reviewer has noted :
" Warmth, water, and poverty are the basic ingredients of tropical life: add a few snails and a dash of feces or urine, and you have Schistosomiasis; the recipe is simple and will serve any number."[2]

Schistosomiasis has attracted a great deal of interest and research in the last decade. National governments, private foundations, and international bodies like the World Bank and the World Health Organization (WHO) have become involved with the complex problem. Long-term studies of epidemiology, pathology, and control measures have begun in Egypt, Sudan, and Nigeria. The control of Schistosomiasis is still difficult, expensive, and, in general , unsatisfactory [2]. Progress has been made in some areas, but at great cost in money and time. Several approaches are possible. Mass chemotherapy could kill the adult worms in the host, cutting off the flow of eggs, but, despite recent pharmacological advances , existing drugs are too dangerous and not effective enough. In any case, re-infection is almost inevitable. Improved rural sanitation, safe wells, and education would be obviously beneficial, and would retard the transmission of Schistosomiasis, but rapid progress in these areas is extremely unlikely. Intensive vector control projects using techniques such as poisoning snails with copper sulfate (chemical control) and other compounds, vegetation control, or designing irrigation systems to exclude snails have been conducted with varying degrees of success in Egypt and in few places in tropical Africa, like for example Zaire and Sudan. Control of

snails by fish, insects, and other biological agents is being studied, as are cheap, bio-degradable toxins from indigenous plants.[2] New attention is given to studies of human behavior. Comprehensive control strategies based on knowledge based on the habits of man, the parasite, and the vector seem essential. Sanitary and water-supply improvements would help in reducing the disease. Reducing exposure to contaminated water depends on adequate village wells, docks for boats, and other expensive improvements; it seems unlikely that children can be kept out of cool water on hot days. Such improvements, combined with education, therapy, cost-effective vector control techniques, and perhaps vaccines, hold much promise for the future. Given reasonably favorable political and financial situations, substantial control of Schistosomiasis is possible over the coming decades.[2]

From the previous discussion it was noticed that if the life cycle of Schistosomiasis could be broken then the disease could be controlled. Of course treatment of infected people is available but it proved to have side effects that are very bad. So, as a result, it's better to prevent the disease from infecting people rather than to try to cure the already infected people. From the previous discussion it was obvious that the best way to break the cycle is to control the snails ,which are the intermediate host of both kinds of schistosomes namely Schistosoma Mansoni and Schistosoma Haematobium. And this is so in order to prevent the disease from reaching the human being.

1.2.2.8- Objectives of the thesis

Snail control or prevention ,which is the objective of this thesis will be discussed through one or more of the following techniques:

1) biological control, 2) chemical control and 3) physical control which is divided into mechanical control and the control through better irrigation-systems designs and practices.

Each control method has its advantages , as well as, disadvantages, which will be discussed throughout the thesis. Those advantages and disadvantages are the criteria that would be the basis for choosing one or several combined methods to control the spreading of the snails.

Chapter (2)

LITERATURE REVIEW

2.1- Snail control techniques :

This chapter will discuss the three previously mentioned control methods of the snails. It will also draw a comparison between the different methods and show their advantages as well as disadvantages.

2.1.1- Biological control of snails

Snails are biologically controlled by allowing their natural enemies such as ducks, fish, other types of snails, crabs, bacteria, fungi, flies, bugs and plants, to live in waterways, where the snails are existing in order for those natural enemies to attack the snails. Another set of biological control means against the snails are, changing the sex of parasites, histological changes, starvation and infection of the snails. The following are some studies done to fight or control the snails biologically:-

1- Several recent studies were made on using *plants* to fight or control the snails; the following are some examples of them:-
In 1994, Refahy [21] at the Theodor Bilhartz Institute in Egypt found that the two Egyptian plants called Dyzygothica elegantissima and Dyzygotheca kerchoveana (from family Araliaceae) showed

molluscicidal properties against Schistosomiasis transmitting snails, Biomphalaria Alexandrina and Bulinus truncatus and could be used as a biological control means.

In1996, El Emam [22] at the Theodor Bilhartz Institute conducted a study, investigating the effect of the plant Anagallis arvensis as a biological control meassure So the dry powder of the plant Anagallis arvensis were used in El Liba village , Sharqia governorate to control the snails and showed sucess.

In 1996, Paumgartten [23] and Speit in Brazil found that the latex of *Euphorbia milii var. hislopii* is a highly active plant molluscicide for snail control and is not mutagenic in mammalian cells.

In 1997 Brackenbury and Appleton [24] , found in South Africa, that, dried leaf material of a Mexican plant, *Agave attenuata*, was found to be highly toxic to the snail *Bulinus africanus*, the intermediate host of Schistosoma hematobium in South Africa. The molluscicidal potency of the plant underwent seasonal variations, but remained stable over a range of pH values. The toxicity of the molluscicide to crop plants, invertebrates, fish and mammals was lacking or low. This concluded that A. attenuata may be provided as a substitute for niclosamide. They investigated the effects of *Apodytes dimidiata* as a biological control. The crude aqueous leaf extract of a South African tree *Apodytes dimidiata*, has been identified as a potential molluscicide for snail control. Among the botanical molluscicides, *Phytolacca dodecandra* shows the greatest promise in controlling freshwater snails harboring the parasites causing Schistosomiasis. Also *Ambrosia maritima* is used to control Schistosomiasis parasites.[25]

In 1997, a group of scientists from Theodor Bilharz Research Institute and faculty of agriculture of Ain Shams university [26] , studied the

effect of the plant Azolla Pinnata on the survival, growth rate and hatchability of egg masses of the snail Biomphalaria Alexandrina. Results indicated that Azolla Pinnata plants reduce the growth rate of the snails. The higher the plant density the lower the growth rate and vice versa. Also indirect exposure of newly hatched B. Alexandrina resulted from exposed treated eggs reduced the growth rate of these snails. Data indicated that direct and / or indirect exposure to the abnormal high density (50,000 plants/L) resulted in complete kill of B. Alexandrina snails after two weeks from continuous exposure. Snails exposed directly to Azolla at 50,000 and 25000 plants/L failed to lay eggs. On the other hand, snails exposed to 10,000 plants/L laid few eggs compared with unexposed ones.

In 1997, Ahmed and, Ramzy [27] did a laboratory assessment of the molluscicidal and cercaricidal activities of the Egyptian weed, Solanum nigrum at the Institute of Research for Tropical Medicine, in Cairo, .The molluscicidal properties of Solanum nigrum L. were tested against three Egyptian snail species (Biomphalaria Alexandrina, Biomphalaria Glabrata and Bulinus truncatus), each an intermediate host of parasites causing human Schistosomiasis. The plant was collected in two regions within Egypt: Fayium and Giza. Snails were exposed for 24 and 48 h, to the dry powdered fruits and leaves or to crude water extracts of the powders, and mortality was recorded. The water extract of the leaves collected in Fayium(FLWE) had the highest molluscicidal activity, with median lethal concentrations (LC50) of 18.6 mg/liter for Bi. Alexandrina, 14.5 mg/litre for Bu. truncatus. When Bi. Alexandrina infected with Schistosoma Mansoni were exposed to FLWE (20 or 25 mg/litre),they shed significantly fewer cercariae than unexposed snails ($P < 0.02$). The cercaricidal properties

of FLWE were directly tested against S. Haematobium, S.mansoni cercariae and a time-concentration relationship was observed; the concentrations needed to kill all cercariae (LC100) within 30min of exposure were 30 mg/litre for both S. Haematobium and S. Mansoni.

2- Controlling snails by *fish* is another mean to fight Schistosomiasis.

In 1994,Slootweg and Malek [28] found that, the use of *molluscivorous fish* for biological control of snails can also be effective.

In 1997, Chimbari and Madsen [29] investigated the potential efficacy of *Sargochromis codringtoni* in the biological control of snails carrying schistosoma. A single fish consumed > 800 snails within three weeks. There are also many other types of fish that could be used as a snail control agent.

Using *crayfish* - exmp. *Procambarus clarkii* - [28] proved a good control of snails.

Lepomis microlophus, the "shell-cracker" fish [28] has been used in the control of snails in fish ponds in Puerto Rico with some measures of success.

The introduction of *Gambusia* fish [30] into snail habitats in the Sahara has been reported to cause a marked reduction in intermediate host populations. Further research here will be worth.

3 Impact of *infection and starvation* on mating in Biomphalaria glabrata could work as a control.[16]

4 Another mean of biological control is using *competitor snails* such as for example *Melanoides tuberculata* against Biomphlaria spp.-host of S. Mansoni in Venezuela.[34]

The presence of *Marisa cornuarietis* [34] was responsible for enhanced growth of B. glabrata and for a *change in the sex ratio* of S. Mansoni, which became more male-biased.

Helisoma duryi, a planorbid snail from Florida, was found by Dr. Mandahl-Barth [34], head of the Danish Bilharziasis Laboratory , to play a significant role in the biological control of Bulinus truncatus snails under laboratory conditions in Denmark

Tarebia granifera, in Puerto Rico, can displace the snail B. glabrata.

5- A total of 110 *bacterial isolates* were investigated for their molluscicidal activity, against newly hatched, first week age Biomphalaria glabrata.[16] These bacterial isolates were collected from different sources including dead snails' tissues, mud and soil. None of the gram positive rod isolates was active as a biological control agent . In contrast, 13 out of 25 gram negative rod isolates showed remarkable molluscicidal activity, ranged from > 50% to 100% mortality, of the exposed newly hatched , first week aged snails. However, only 4 of these showed similar results against juvenile, 2 -3 weeks age, snails. On the other hand , only one Enterococcus sp. Out of 17 gram positive cocci showed mortality rates up to 100% against both newly hatched as well as juvenile B. glabrata snails. The bacteria used to fight the snails) is usually of the type Bacillus pinoti.

6 In 1990 it was found [31] that using *prawns* as a biological control mean of snails showed also a great success. Laboratory experiments

were conducted on predation by the giant freshwater prawn, *Macrobrachium rosenbergii* , on Biomphalaria glabrata . Prawns greater than 22 mm carapace length could consume snails of any size.

7- *Scyomizid flies* [15] have been tried by Dr. Berg in the laboratory at Harvard and elsewhere. Their aquatic larvae pounce on the snail, plunging their pincers into its body ; the snails usually bleeds profusely and dies. The value of these larvae in snail control in the field has been verified.

8- *Limnogeton fieberi*, a 4 to 5 cm long aquatic *bug* living in the Nile Delta, was proved by Voelker to be an obligatory snail eater. Neither in field nor under laboratory conditions were these bugs seen to attack other animals (fish, amphibia, orthropods). A daily average of 2.7 snails per bug were killed . It is probable that this bug plays a role in reducing the Bulinid snail population in Egyptian waters.

9- In 1997, El Damhougy and Ibrahim [32] , Al-Azhar University, Egypt studied the effect of aprotinin on Schistosoma Mansoni miracidial penetration into Biomphalaria Alexandrina. The snails were exposed to S. Mansoni miracidial suspension which was mixed with aprotinin at concentrations ranging from 0.02 to 20 Kallikrein inactivator units (KIU)/ml of applied solution. Results showed that aprotinin had marked inhibitory effect on miracidial penetration of the snails. The concentration that resulted in 50% inhibition of the miracidial penetration into B. Alexandrina snails (LD50) was 2.4 KIU/ml while (LD96) was 20 KIU/ml of the applied solution. Thus, aprotinin could

be considered as one of the important methods in the control of Schistosomiasis.

10- In 1993, El-Kersh [33] et. al. of the faculty of pharmacy, Cairo university, investigated the effect of certain microbial control agents against developmental states of Biomphalaria Alexandrina snails. Microbial isolates recovered from various specimens as snail's tissues, stagnent water deposits..etc and cultivated on specific media under appropiate conditions, were tested for its activity against developmental stages of Biomphalaria Alexandrina snails. A number of observations have been mentioned on the egg-masses (5-7 days old) that were placed in 2 ml of microbial isolate in 2 ml sterile water, for 1-2 days at 25C. The larval snails were observed within the egg and mortality was determined after recovery periods of 2 days. It was found that, the percentages of snail's eggs hatching (control and treated) were 10% and 10% respectively. Moreover, the effect of these microbial isolates on newly hatched snails was studied. The data obtained showed that percentage of death within the treated snails were 80-90%. Also, the microbial isolates were tested against adult snails which supress their biological and physiological functions as snails-laying egg capacity, ovulation…etc.

11- In 1998,Yousif, et. al. [34] Department of Medical Malacology, Theodor Bilharz Research Institute,investigated the effects of six non-target snails on Schistosoma Mansoni miracidial host finding .Six snail species naturally associated with Biomphalaria Alexandrina, the snail host of Schistosoma Mansoni in Egypt, were tested under standard laboratory conditions, for impact on miracidial host findings and

infection of the snail host. These snails are the prosobranchs Melanoides tuberculata, Cleopatrabulimoides, Bellamys unicolor and Lanistes carinatus, the pulmonates Planorbisplanorbis and Physa acuta. The tested snail ssp. reduced considerably the infection rate of Biomphalaria with S. Mansoni especially at a ratio of 10 decoy snails (decoy snails means bluffing or non-target snails) to one Biomphalaria snail.

2.1.2- Chemical control of snails

Another mean for controlling snails is the chemical control. This method uses some molluscicides, the most widely used ones of them are Copper sulfate and the Niclosamide. Also using agro - chemical molluscicides is worth to study. There are also some chemical compounds called candidate molluscicides that could be used as a chemical control measure. This is an effective way to kill snails but it proved (chemical control) to be expensive and environmentally unsafe. Another way of chemical control is by using bacterioscides and fungiscides. The following are some of the chemical means used to control the snails:

1. The use of *Copper sulfate* and Bayluscide [39] killed two types of Egyptian snails (Biomphalaria Alexandrina and Bulinus truncatus) very effectively by all concentrations. But Biomphalaria Alexandrina was more sensitive to them.
2. In 1994 a study on the molluscicidal effect of Earth Tec: an environmentally responsible copper sulfate product was conducted by

Hady, et. al. [35] at the Department of Parasitology, Faculty of Medicine, Ain Shams University, .Studies were carried out, under laboratory conditions to evaluate the emolluscicidal activity of Earth Tec on Biomphalaria Alexandrina snails, the intermediate host of Schistosoma Mansoni. Earth Tec is an environmentally responsible copper sulfate product manufactured and marketed as an algicide/bactericide with an active ingredient form of copper ion (Cu++). A single application, of 1 ppm of copper equivalent, for 24 hours caused 100%mortality rate of the snails. Exposure for 48 hours to 1 ppm and 2 weeks to 0.25 ppm caused mortality rates of 84% and 100% respectively. It was concluded that this chemical compound is a promising molluscicide. Field studies are ongoing and will be published in due time.

3. The use of *Niclosamide* [39] also proved to be effective in killing snails. But some biological agents proved to be a substitute for it to overcome niclosamide's bad environmental effects (see biological control section).

4. In 1998, El-Sawi, et. al. [36] , College for Women, Ain Shams University, conducted a study on the molluscicidal action of some isatin derivatives against Biomphalaria Alexandrina. Some compounds selected from the isatin derivatives and their metalleted products were used to study their molluscicidal effect on Biomphalaria Alexandrina. The results indicated that some of these compounds showed good results and seem to be promising molluscicides.

5. *Agro-chemical* selection regarding molluscicidal potency and pest resistance of Phytolacca dodecandra types is worth to be studied. A method of application by putting a P. dodecandra berry suspension into running water of a river during the dry season in Bati, Northern Ethiopia, showed that the presence of snails could be reduced to nil.

6- A number of compounds with varied merits are mentioned below as " *candidate*" molluscicides. They are the following:

a-*Herbicides as molluscicides*

Acrolein is a herbicide to control aquatic weeds and is applied to give a concentration time value of 30-75 p.p.m./hour. At herbicidal concentrations, it kills snails, their eggs and cercariae. Field trials in Puerto Rico, the Sudan Gezira, Tanzania and Egypt have shown effective control of snails and weeds in irrigation systems. It should be handled and used with rigid precautions. This is because it is acrid in smell and irritating to eyes and mucous membranes.

Parquet and Diquat are soluble compounds and are applied in a concentration of 4 to 6 p.p.m. with 24 hour exposure. These compounds are not affected by sunlight or pH , but are reduced by mud. They are rapidly absorbed by algae, but still retain their activity. They do not kill fish at molluscicidal concentrations. They are relatively toxic for mammals, but can be handled safely. The price of these compounds is relatively high.

b-*Insecticides as molluscicides*

Carbamates were reported to have a prolonged effect and not to kill fish. They produce relaxation of the snail body , a property which could be used to enhance the action of other molluscicides. High concentrations ,if required, kills some species of fish.

Orango-phosphorous compounds also show resistance against the snails ; it also causes relaxation of the snail body , which is extended outside the shell.

c-*Fungicides and Bacteriocides as molluscicides*

Organo-tin compounds are basically stable and not seriously degraded by environmental factors. Eggs and newly hatched snails are specially sensitive to those compounds.

Organo-lead compounds influence newly hatched snails more than the eggs.

Halogenated salicylanilides are also compounds that help in killing snails.

Characteristics of good molluscicides

There are certain generally desirable characteristics of molluscicides, the following are examples of them : 1) low toxicity for man, domestic animals, crop fish, and the natural biota should be restored quickly after its use, 2) it should be reasonably safe in the hands of trained but low-grade personnel, 3) it should be active at low concentrations, in order to reduce the cost and trouble of transportation to the points of application, 4) it should be stable in storage and in the habitat after its use, 5) it should kill snails and their eggs, and preferably the meracidia and cercariae also, 6) it should be usable with simple durable equipment, or none at all, 7) simple reliable tests should be available to measure even small concentrations in the habitat and 8) it should be relatively cheap. Till now, no molluscicide satisfies all these characteristics and a good molluscicide may lack one or two of them.[16]

2.1.3- Physical control of snails

Another very important mean in controlling the snails is the physical one. This method is divided into two sub-methods:- irrigation and mechanical control measures.

The following will present examples of such physical means:

1. The effects of *ultraviolet(UV) and gamma irradiation and praziquantel (PZQ)* treatment on groups of 26 Schistosoma - infected laboratory - bred Biomphalaria Alexandrina were investigated. Gamma -Irradiation and PZQ treatment induced higher rates of snail mortality than UV-irradiation. Cercarial production was severely reduced as a result of UV- and gamma irradiation and PZQ treatment. Gamma - Irradiation and PZQ treatment caused histological changes in the snail hermaphrodite gland and cercariae.

. Using electricity could be also beneficial as a snail control technique. Under laboratory conditions low frequency pulses of direct current (d.c.) caused A. glabratus dispersed in shallow water to migrate in a straight line toward the negative electrode , and like that it could be collected.

3. The use of ultrasonic waves on Biomphalaria Alexandrina snails proved to be a very good physical control method, because it kills the snails effectively.

4. In 1996 the Effect of X-ray on the snails of Schistosomiasis in Egypt was investigated by Haroun, et. al. [37] at the Theodor Bilharz

Research Institute in Cairo, .Biomphalaria Alexandrina and Bulinus truncatus snails were exposed to sublethal doses 0.2, 3, 5, 10 and 20 rad of X-ray. The survival and reproductive rates of these snails were highly affected by these doses. The maximum survival periods of laboratory populations of Biomphalaria snails were less than those of field ones which means a high sensitivity of laboratory snails to X-ray. There productive capacity of irradiated Biomphalaria and Bulinus snails was highly suppressed and this will interrupt Schistosomiasis transmission. A deleterious effect of gametogenesis of irradiated Biomphalaria was histologically proved. After 3 weeks of snail irradiation with high dose (40 rad) the hermaphrodite gland became completely evacuated.

5. Another physical control mean is to line the irrigation canals, to cover the canals and to introduce sub-surface drainage. This will minimize Schistosomiasis by eliminating direct contact (of farmers) with contaminated drainage water.

6. Using river or canal flushing system [17] is also one of the physical control measures. Here water is prevented from reaching a canal (by closing weirs and gates) so the canal will dry out and as a result all snails will be killed. After that, water will enter the canal with the purpose to flush it and clean it.

7. Clearance from weeds. Aquatic vegetation provides the snails with food, shelter, and sites for oviposition [16] ; it also slows down the current, rendering the habitat more suitable for life and snail breeding.. Therefore weed control constitutes an essential part of snail

control. Weed control is either chemical (could be environmentally unsafe) or mechanical . Mechanical weed clearance is accomplished by dredging, pulling out by specially designed scrapers , burning, chaining, cutting, mowing and grazing. With mechanical methods, snail habitats are either destroyed or seriously disturbed ; however, such disturbance may also facilitate the movement of the snails by floating them down to new areas.

8. Dryness is also inimical to aquatic vegetation and to snail growth and reproduction. No schistosome transmission occurs without water. Therefore , measures are desirable which will enhance or prolong the dryness of irrigation and drainage channels, within the limits of agricultural requirements. Fortunately these same measures are also desirable to save irrigation water. The following principles have been adopted in Egypt [17]:

a-Water channels should have proper contours and a gradient sufficient to prevent slow current; for same reason they should have no sharp curves. Pot-holes, sudden narrowing or deep siphoning at bridges, roads etc., should be avoided. Regular weed and silt clearance is also necessary.

b-There should be no blind ends to either irrigation canal or drains.

c-All disused watercourses, seepage water collection etc., should be filled in.

d-Irrigation from terminal field channels should be by "lift" rather than "free-flow" or "gravity" irrigation. This will ensure that these field channels will remain dry for long periods and that there will be no ill usage of the water. Lifting of the water should be carried out by small

portable motorized pumps , which can be supplied through the agricultural co-operative societies; this will render obsolete the harmful old methods, such as the "Archimedes Screw" (tamboor) or the counter-balanced lever (shadoof), which necessitate prolonged contact with infective waters.

e-Land leveling and grading contribute greatly to irrigation efficiency and the physical control of snails. The land should be sub-divided into units of about 100 acres, each served by independent canals and drains. This will facilitate the drying out of the canals and drains on the "off" days, as well as the application of molluscicides or herbicides when necessary.

f-Sprinklers or overhead irrigation, wherever possible, will do away completely with the snail risk. It will also save 20% of the land area, because it will dispense with canals, drains and embankments, thus, also saving the cost of land leveling. It will save two thirds of the amount of water needed, thus enabling the cultivation of thrice the area of land with the same amount of water. Lastly, it prevents water logging of the land and thus causes as much larger crop production.

9. Mechanical barriers or screens for pumps, canals and drains, have been suggested to prevent the influx of snail egg clutches into newly established irrigation systems [16] , or systems freed from snails by application of molluscicides. However, a screen mesh small enough to accomplish this would be so close as to create problems of "loss of water-head" and would also be readily clogged, requiring continuous vigilant maintenance and immediate replacement of torn sections by spare screens. Partial (incomplete) barriers are an established control procedure in the Gezira irrigation scheme and its "Managil

Extension" in the Sudan and were also used in Tahrir Province in Egypt. They are made of iron rails and a wire screen with 8 meshes to the linear inch (approximately 3 per cm) all painted to prevent rust . The barrier is L-shaped with the horizontal shelf at an angle of about 80 to the vertical part and is installed near the inlets of the canals . The erect part reaches about 70 cm below the water surface and serves to screen the top layer of water containing the floating debris with the attached snails and snail egg clutches, which are then retained by the horizontal part; they are removed daily and the snails are counted. In "Tahrir Province", for example, the snails caught at the barrier amounted in 1960 to 237 Bulinus and 71 Biomphalaria, while in 1961 the catch was 191 Bulinus and 59 Biomphalaia. Records from the Gezira barrier showed an average monthly catch of 1616 snails in 1957-58 and 3407 in 1958-59.

10. Put traps at inlets (nets, palm leavs,..etc). Snails like to dwell and lay their eggs on palm leaves so those leaves could be used as baits or traps for the snails, this is done by inserting palm leaves in the side slopes of the waterways (up to 30 cm inserted in the slopes) then when it attrackts a large number of snails and egg masses those leaves are taken out of water and are either buried or burned.

11. Use Borehole wells and study their effect on water utilization.

1 .Shade as a means of ecological control (because snails are attracted to light and are negatively affected by darkness).

1 .Use some hydraulic structures like siphons, culverts, bridges, lateral spillways and drop structures to lessen the contact of the human beings with the water.

14.Controlling the pH, velocity of current and the temperature helps so much in controlling or preventing the snail growth. The snails cannot withstand high velocities, high pH, and low temperatures.

2.2- Comparison between the three snail controlling methods :-

From the former discussion it could be concluded that each snail control method (physical, biological and chemical) has its advantages as well as disadvantages. Also there are some methods that best suite a particular situation than other methods.

For example, ***biological control*** would offer economic advantages, but more experiments in this field should be done in order to take care of the dangers (for example disturbing the eco-system and balance of the aquatic life when introducing or implanting natural enemies to the snails in the canals which are beyond the natural capacity of the canal) that could be associated with that type of control. Another advantage of biological control is that it has a direct effect on target snail numbers and doesn't affect other species . Actually this method is environmentally friendly because it uses natural substances(living organisms), also it preserves and doesn't disturb the eco- system. Also the types of plants that are used as molluscicides and are found outside Egypt should be tested for their effects on the snails within the Egyptian environment. There are some other factors limiting this type of control among which

are water level fluctuations in ponds, flooding in streams and rivers, presence of emerged or submerged macrophytes, food quantity and sewage pollution. One of the difficulties associated with this type of control is that of controlling the safety of the natural snail enemies themselves. For example, the fishes and ducks used to control the snails are fished by man and eaten. So to sum-up a large disadvantage of the biological control method is the difficulties associated with its application in the field.

As for the ***chemical control***, it is expensive and also environmentally hazardous, because some kinds of them are dangerous to the fish and other water species. Also there should be a very well trained staff that will apply the molluscicides in the field But on the other hand a big advantage of the chemical control is that some of the chemical compounds are very fatal to the snails at very low concentrations. Another problem associated with the application of the mollusciscides is that for a molluscisiide to be able to reach a branch canal it has to be applied in very large quantities in the main canal or waterway.

The ***physical control*** has a very important advantage which is that it lessens the contact of human beings with water. On the other hand it requires high technology, which is sometimes expensive . Also it requires well trained staff at some of its applications such as the ultrasonic tests, the UV radiation and the gamma radiation. But from the previous discussion it could be concluded that it is environmentally friendly and if the budget permits it would be the most convenient method to use to control the snails.

To conclude one must choose the most effective and the economically feasible control method, the method should also be not hard to apply. To achieve this is not an easy task and more than one control method could be combined to achieve the needed result. In this thesis the focus will be given to the coming up with a new mechanical control technique because as mentioned from the former discussion the mechanical method is environmentally friendly in general and to the aquatic life in specific and, in most situations, easy to implement method. The use of a swirl generator will be introduced in this research thesis and thus many experiments will be done on the design and assembly of this generator as well as on its efficiency in crushing the snails, because actually the swirl generator is a device that will be used to crush the snails. So the next step in this thesis, after the literature review that was done to better understand and build on the efforts done to fight the existence of Schistosomiasis,is to design a swirl generator and test it in crushing the snails. There is also another apparatus that will be introduced in this research thesis which is namely the screens mechanical cleaning device. This device is to be placed after the swirl generator apparatus in order to have a double protection system.

The snails used in the experiments are baby snails because those are the most difficult size of the snails to combat because it is so small, between 1 to 3 mm in diameter.

Chapter (3)

EXPERIMENTAL INVESTIGATIONS

3.1- Introduction

The objective of this research is to control the schistosoma snails in a new mechanical way. The mechanical way is favored over the other ways of control because it doesn't harm the environment and the aquatic life (or the harm is very minimal and could be neglected).

It should be noted that the snails used for the purpose of this research are baby snails - 1 mm to 3mm in size - . This is so because the baby snails are the ones which are always hard to kill by mechanical means and escape because they have a tiny size.

Two experimental set-ups will be used to control the snails mechanically. The first set-up is swirling motion apparatus to kill the snails. The second set is the continuous cleaning system for all snails including baby snails without blocking the flow.

The first mechanical method used to control the snails in this research is a new method namely it deals with the swirling motion- or vortex motion- to destroy and kill the snails. The description of the apparatus used for carrying out this purpose will be discussed later in this chapter but before getting into that , the general idea of the experiment and apparatus; as well as, the swirling motion and its characteristics will be explained.

The experiment deals with inserting into the apparatus swirlers with different blade angles, different diameters and different configurations. The aim is to study the effect of those swirlers on the percentage of snail kill and also to determine which of the different swirlers will lead to the highest percentage kill. Another factor like raising the temperature of the setup (along with the existence of the swirlers) is also examined. Actually the forces associating with the swirling motion will cause the snails or snails' shells to be destroyed and thus the snail itself to be killed.

3.2- Swirl flow characteristics

The effects of swirl in flow characteristics are known for many years. Some effects are useful and the designer strives to generate the required amount of swirl for his particular purpose ; other effects are not favorable and the designer always tries to minimize or control them. Swirl flows occur in a very wide range of applications including, vortex amplifiers and reactors, cyclone separators, vortex shedding from aircraft wings, tornadoes, jet pumps, heat exchangers, agriculture spraying machines and also the theory of the Frisbee motion depends on the swirling motion. The swirl flow has also wide applications in the combustion systems namely by the injection of air and fuel in the gasoline engines, diesel engines, gas turbines, boilers and many other applications.[1]

Swirling flow results from the application of spiraling motion, a swirl velocity component - also known as a tangential velocity component- being imparted to the flow by the use of swirl vanes, by the

use of axial-plus -tangential entry swirl generators or by direct tangential entry into the system[1]. The swirling motion results in producing a tangential force to the flow. This force is what is used in the research to kill the snails as shown in figure 22.

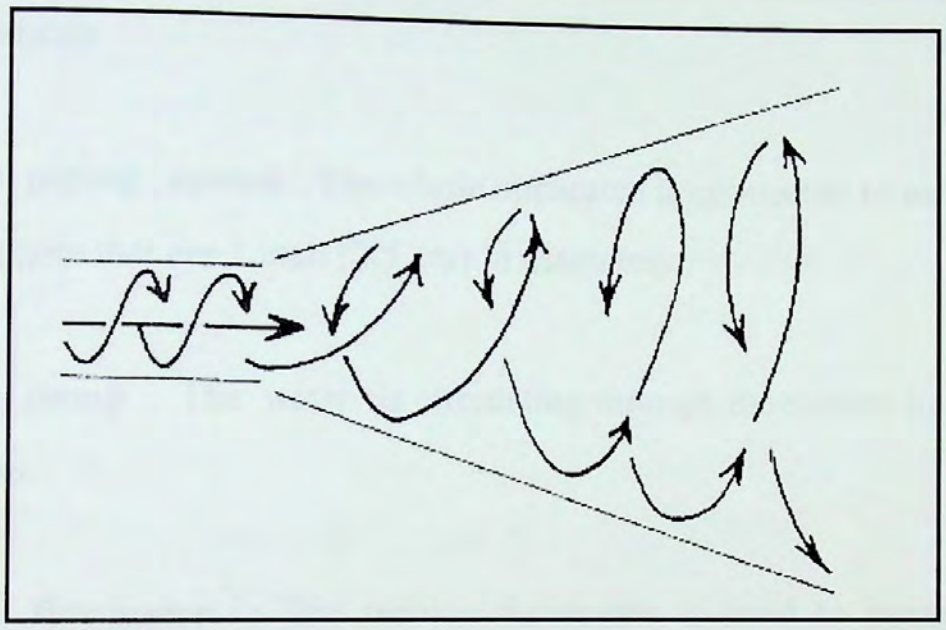


Fig. 22 : The swirling motion

3.3- Experimental apparatus - swirling motion apparatus

The first experimental set-up consists of a transparent pipe to observe the flow, swirl generators and its holder, heater to control the temperature, pump to circulate the flow, turbine flowmeter to measure the flow, and a piping system.

1- **A 10 cm diameter transparent pipe** : It's a component of the piping section of the setup and it is designed and constructed to be transparent in order to facilitate the visualization and observation of the snails while they are moving under the swirling motion. This pipe

is connected directly to the holder that is encapsulating the swirler so it makes it easy to observe the swirling flow from its start.

2- **The entrance "E"**: It's a circular opening in the 10 cm transparent pipe and its purpose is to be an entrance for the snails to the apparatus.

3- **The piping system** : The whole apparatus is connected to each other via pipes that are 1 inch (2.5 cm) in diameter.

4- **The pump** : The water is circulating through the system by using a pump.

5- **The flowmeter** : The turbine flowmeter is used to measure the quantity of water that will pass throughout the system along a period of time. This flowmeter reads in gallons per minute.

6- **Heater** : A heater is attached to the apparatus in order to raise and control the temperature of the water.

7- **The swirlers** : Swirlers will be used to provide the system with the vortex or swirling motion. They consist of 10 blades with different angles. They are fixed swirlers meaning they don't move or rotate, actually the water is what is moving as a result of pumping. A set of swirlers are used which are different in diameters , angles and configurations. Swirlers with angles 15, 30, 45, and 60 are used (the angle of the blades is taken with the horizontal). Different swirler diameters are used, 6 cm and 10 cm. Also a parallel setup is used

where two concentric swirlers are placed into each other; the inner swirler is of 10 cm diameter and the whole setup is 15 cm in diameter as shown in figure 23.

8. **Holder** : The holder is that component of the apparatus where the swirlers are located. There are three kinds of holders used with the apparatus depending on the swirlers' size and configuration (10 cm diameter swirler, 6 cm diameter swirler and parallel configuration of 15 cm diameter). Those holders are removable (not a fixed component in the machine) depending on the kind of the swirler that will be inserted in them.

9 **The inlet of water** : Water enters the apparatus from the near main water source . It enters the apparatus though valve "A".

10 **The valves** : Many valves are controlling the flow in the apparatus. Valve "A" is controlling the entrance of water, whereas valve "D" is controlling the exit of water from the apparatus. Valves "B" and "C" are there to control the flow within the apparatus itself; if valve "C" is closed then the water that enters the machine will exit directly after circulating only one time whereas if this valve is opened the water will circulate many times-as desired. Valve "B" if closed will prevent the water from flowing in the machine on the other hand the water after it enters from "A" will go directly out if valve "B" is closed.

11 **The outlet** : The outlet of the apparatus is where both the water and the snails exit.

12 **Supports** : There are many vertical supports that are supporting the apparatus and holding its different components in their places. Those

supports work as a structural system that distributes the dead load of the machine safely on its various components. For more details see Figure 24 of the apparatus.

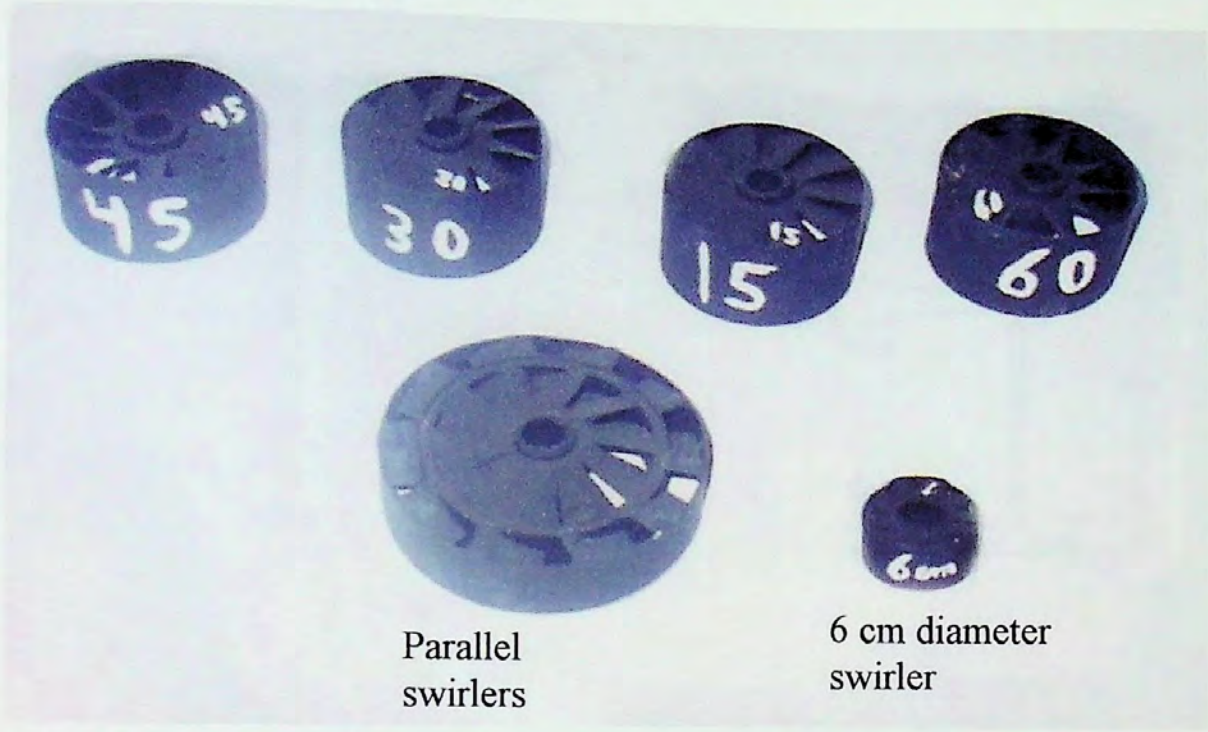


Fig. 23 : Swirlers of different blade angles, diameters and configurations

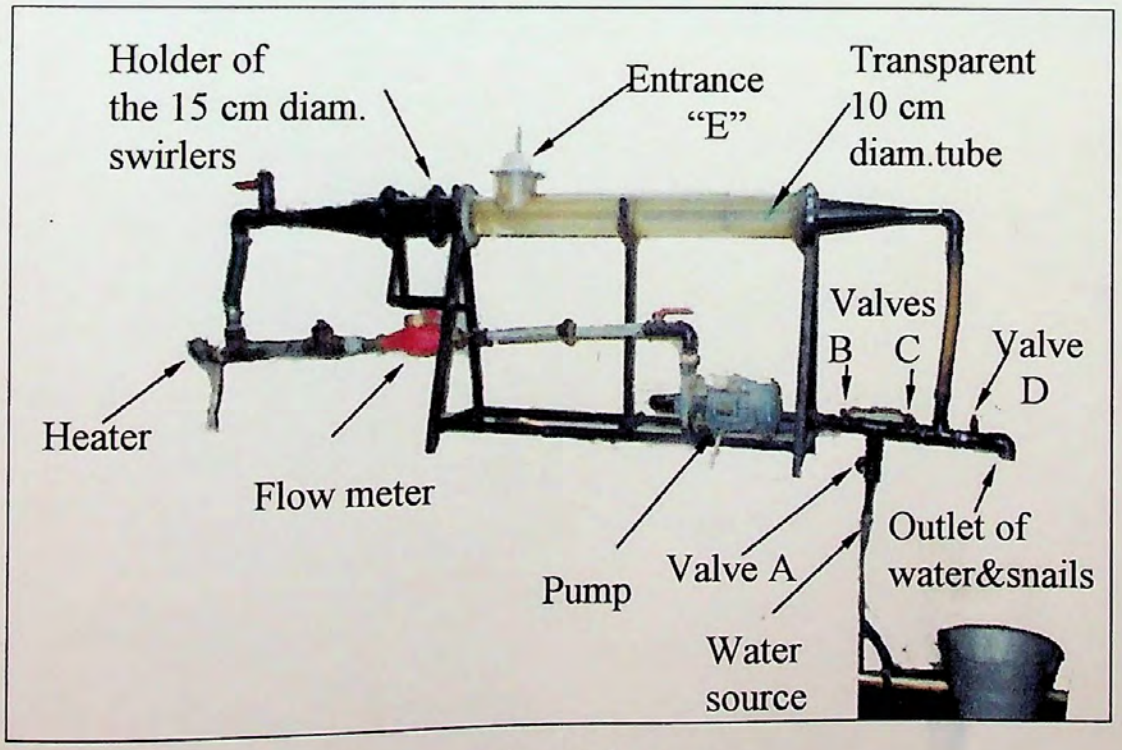


Fig. 24 : A) The swirling experimental set-up

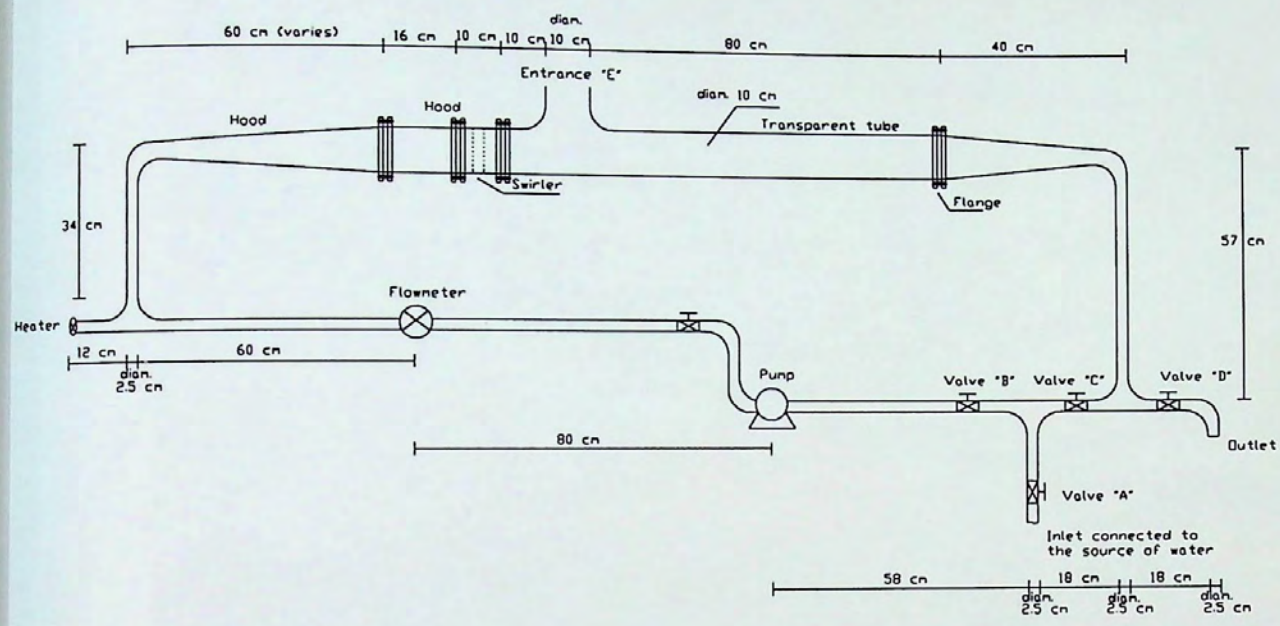


Fig. 24 : B) Cross section of the swirling experimental set-up

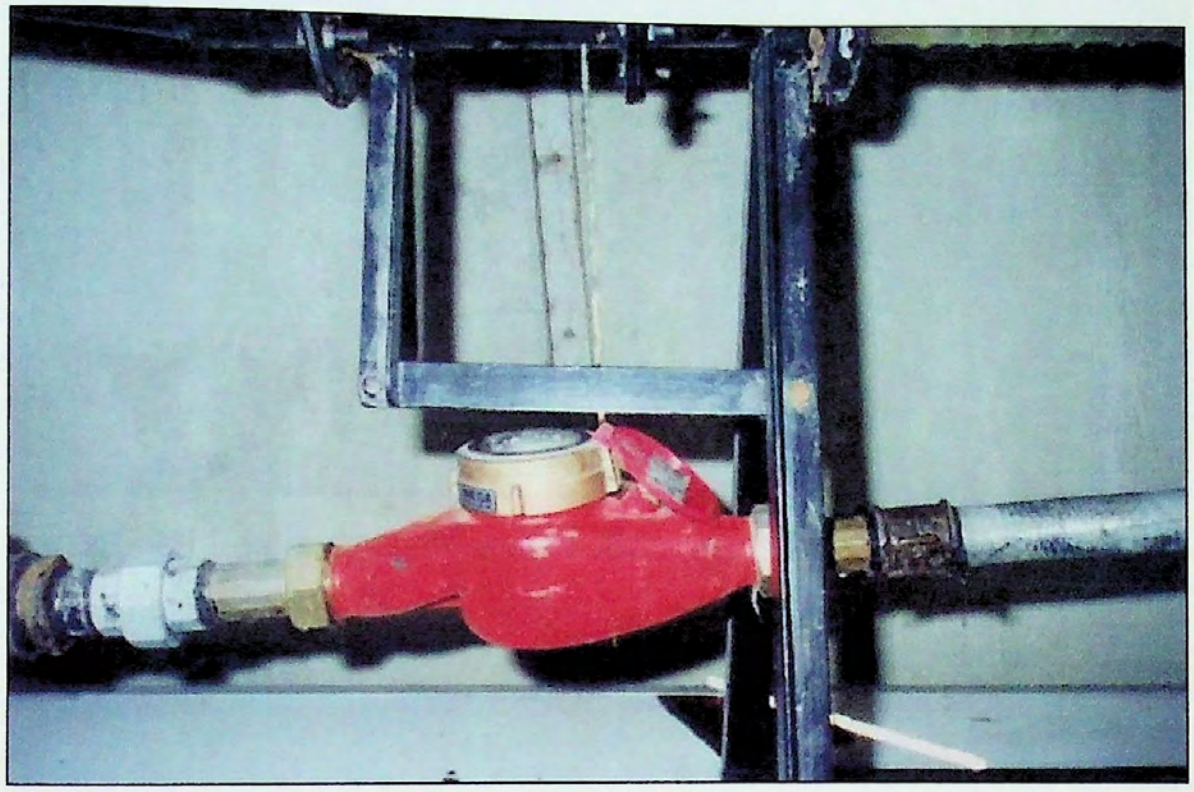


Fig. 24 : C) Turbine flow meter

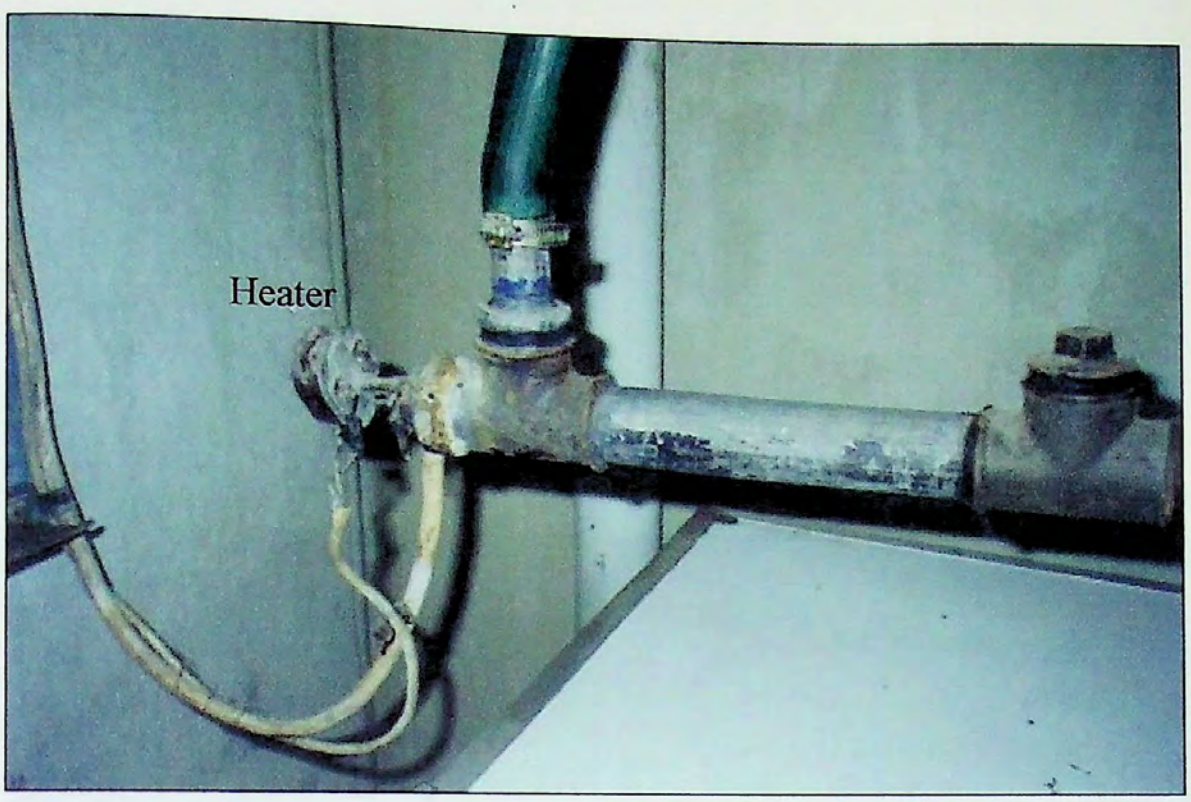


Fig. 24 : D) Heater and temperature controller

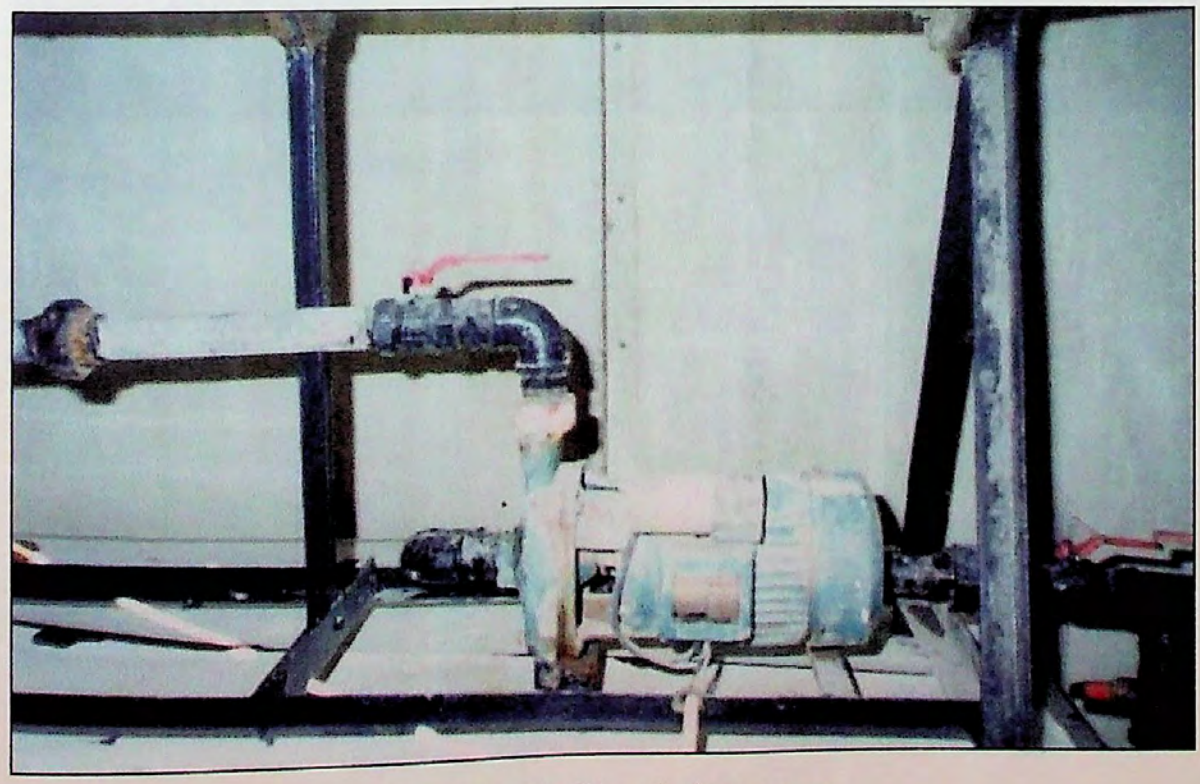


Fig. 24 : E) Circulating pump

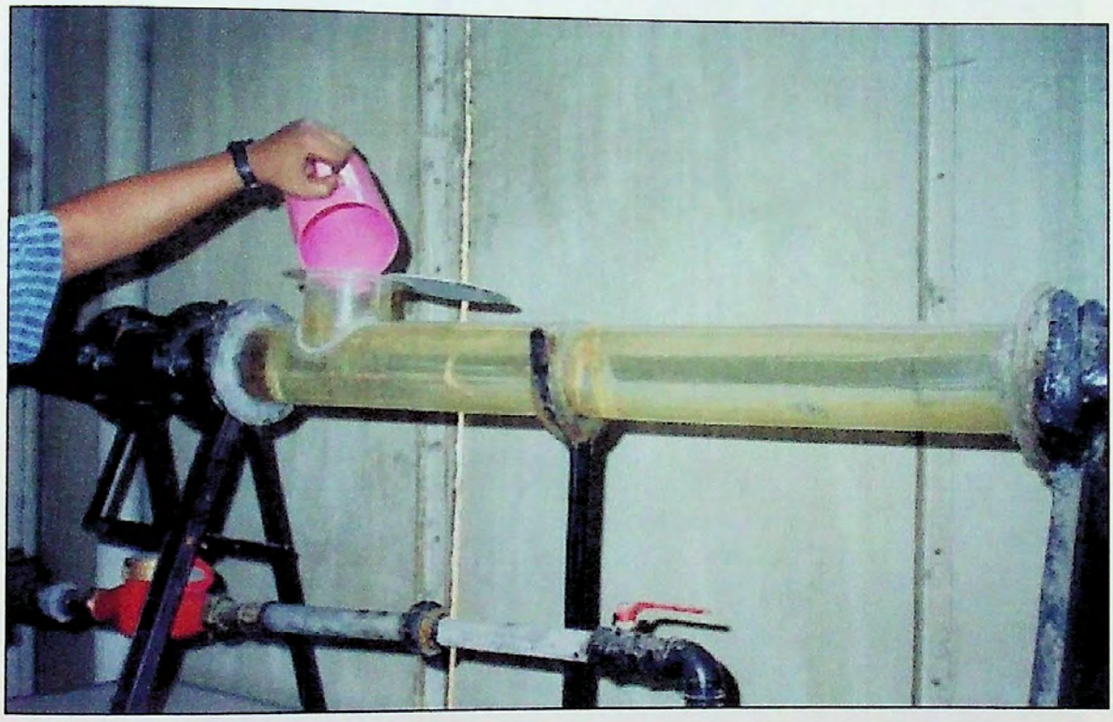


Fig. 24 : F) Snail entrance "E"

Fig. 24 : G) Set-up outlet of snails and water

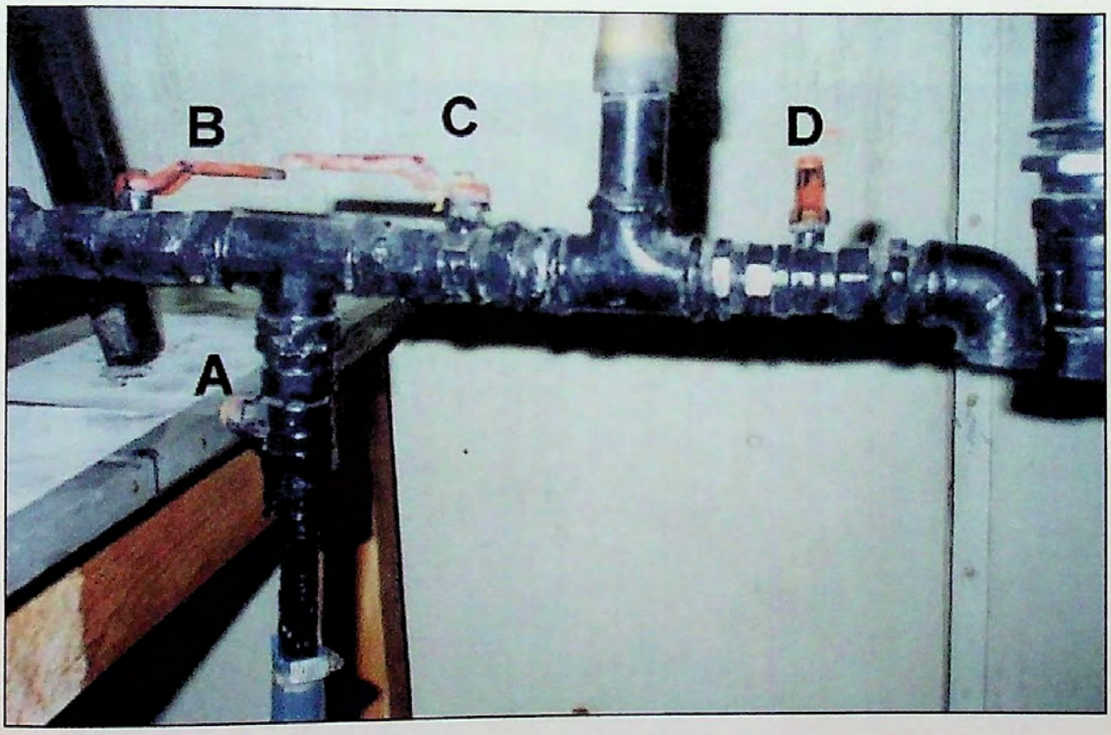


Fig. 24 : H) Control valves

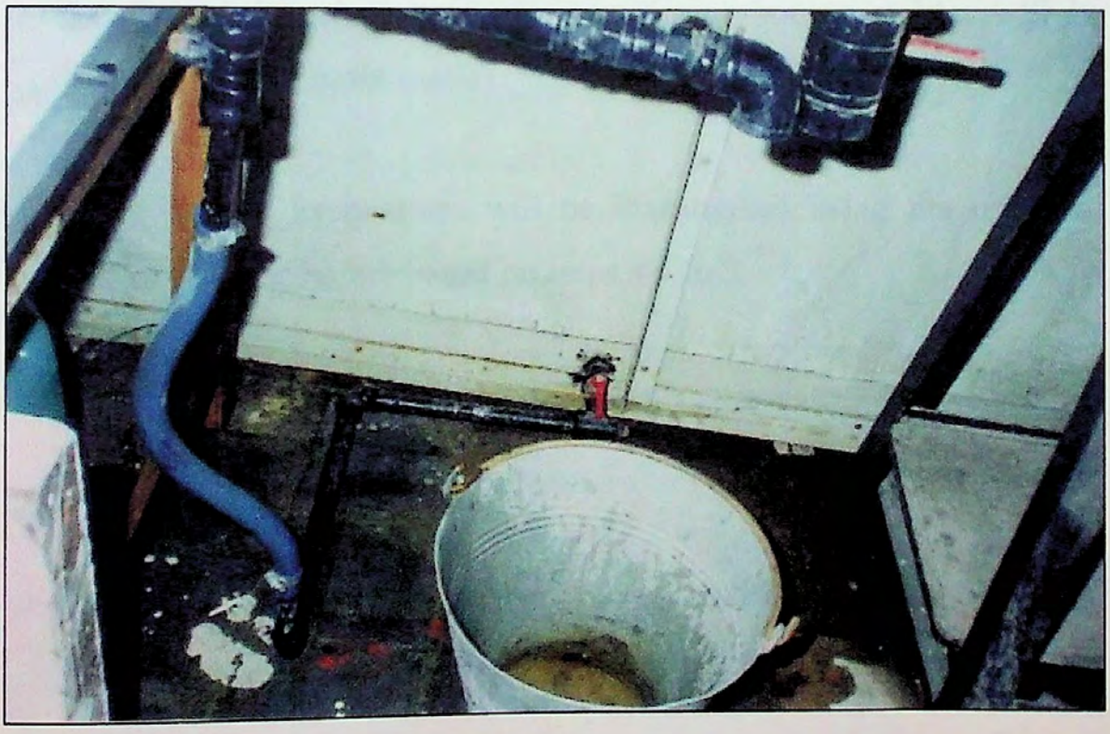


Fig. 24 : I) Tap water source connection

3.4- Experimental procedure

1 Insert the 15 degree swirler into the holder and circulate the Biomphalaria snails for 5 minutes. If the snails are not killed then increase the cycle time and make it 10 minutes. (if the 10 min. does not work then keep increasing the time at 10 minutes intervals until the desired time to kill the snails is reached).

2- The steps of # 1 will be repeated using different swirlers with different angles.

3- Based on the above experiments, the optimum swirler will be selected (killing more snails).

4- Effect of the temperature will be investigated using the optimum swirler selected before based on steps # 1 to 3.

5- Investigate different configurations of swirlers (parallel set-up) and see the effects.

6- Use the best swirler to experiment on the other kind of the Schistosomiasis namely the Bulinus ginus.

3.5- Experimental apparatus - continuous fine screen cleaning system

At any intersection of two canals where a hydraulic structure such as culvert, aqueduct, siphon ..etc., is placed there must be screens located at the inlet of that structure. Actually some times they are multiple screens that are put in series starting from a coarse screen to retain large flowing debris, to small mesh size screens that will retain small floating objects. The function of the screens is to protect the hydraulic structure from any floating debris that would damage it and clog it if it enters in.

As mentioned before the swirling machine setup will be placed at the intersection of two canals; so because of that screens should be placed at the inlet of the swirling apparatus (detailed design and operation in the field will be discussed later in the thesis).

The fine screen that is designed in this research will be the last to be placed in the series of screens. Meaning it will be the last one after exiting the swirling apparatus. It is a very fine screen because it will retain the baby snails from entering the swirling setup.

Because the screens get always plugged from the accumulation of the debris in front of them a cleaning system is needed in order to overcome this problem. In this research a mechanical continuous cleaning system is designed to clean the screens.

The apparatus , as shown in Figure 25 consists of the following components:

1- **Two concentric tubes within each other** : The outer tube is of a 23 cm diameter and the inner tube is actually the screen and is perforated. It is 17 cm in diameter.

2- **Annular area** : This is the space (void) between the inner and outer tubes . From here the clean water will be received.

3- **Outlets** : There are two outlets in this apparatus; one is for the clean water "exit "A" " and one is for the debris and baby snails that are received after screening "exit "B" ".

4- **Inlet** : The inlet is for the water that is contaminated with the snails.

5- **Pump** : The purpose of the pump is to circulate the water through the apparatus.

6- **Brush** : The function of the brush is to clean the screen from the snails and other fine debris that will stick to it.

7- **Gears** : There are two gears one is horizontal and is connected to a vertical one which is in turn connected to the brush. The function of the vertical gear is to transmit the motion from the horizontal gear to the vertical brush.

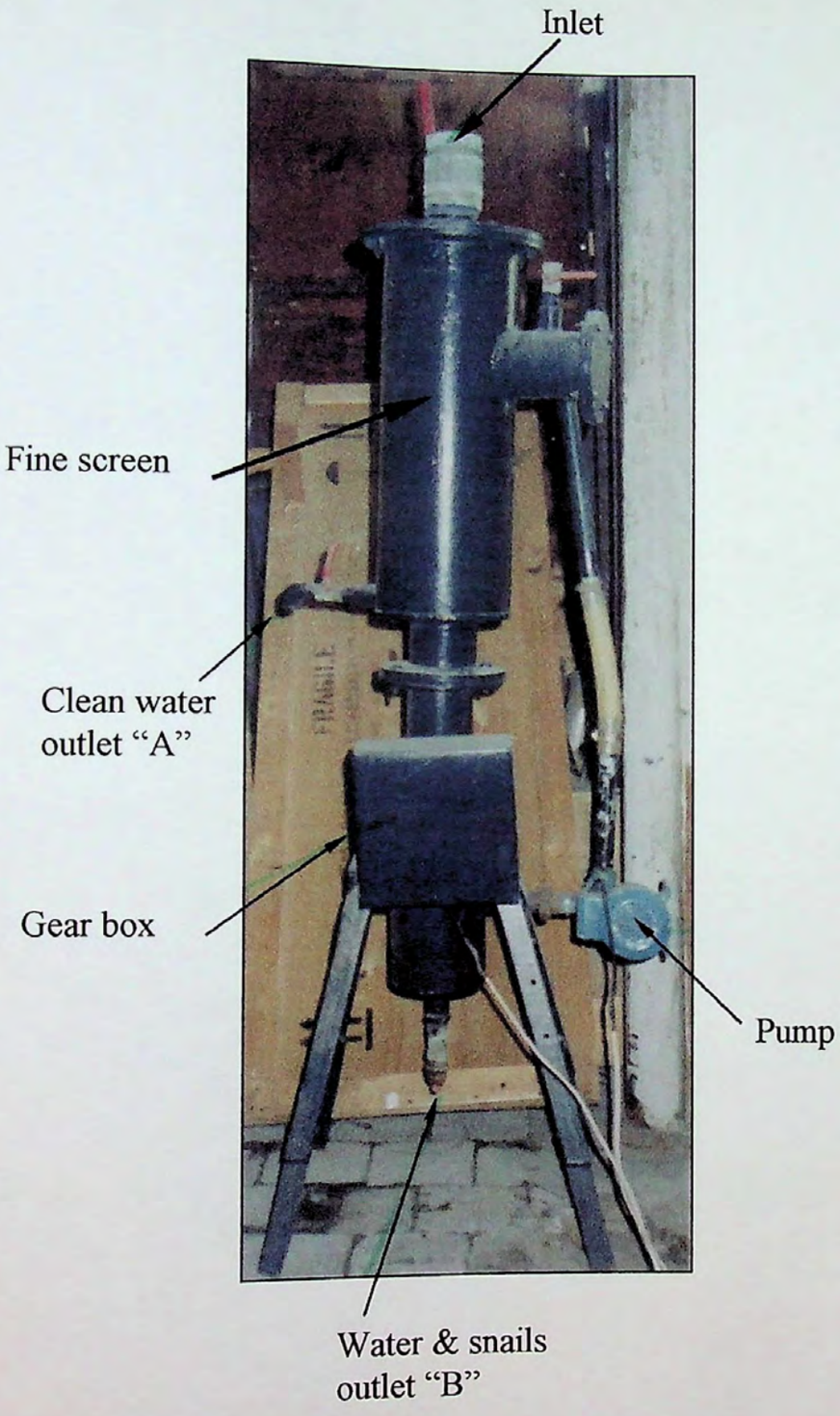


Fig. 25 : A) The screen continuous cleaning setup

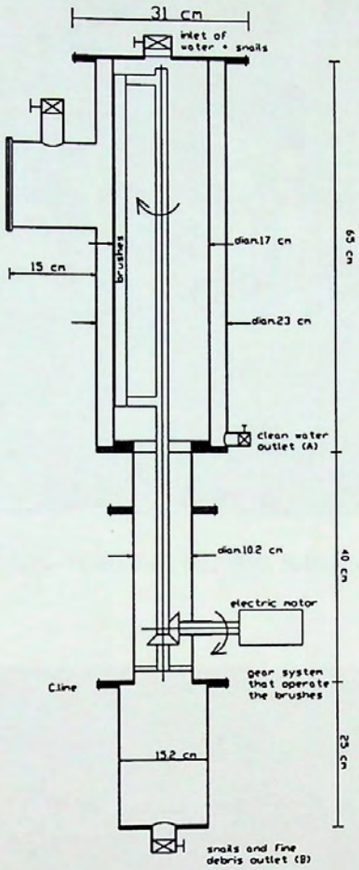


Fig. 25 : B) Cross section of the screen continuous cleaning setup

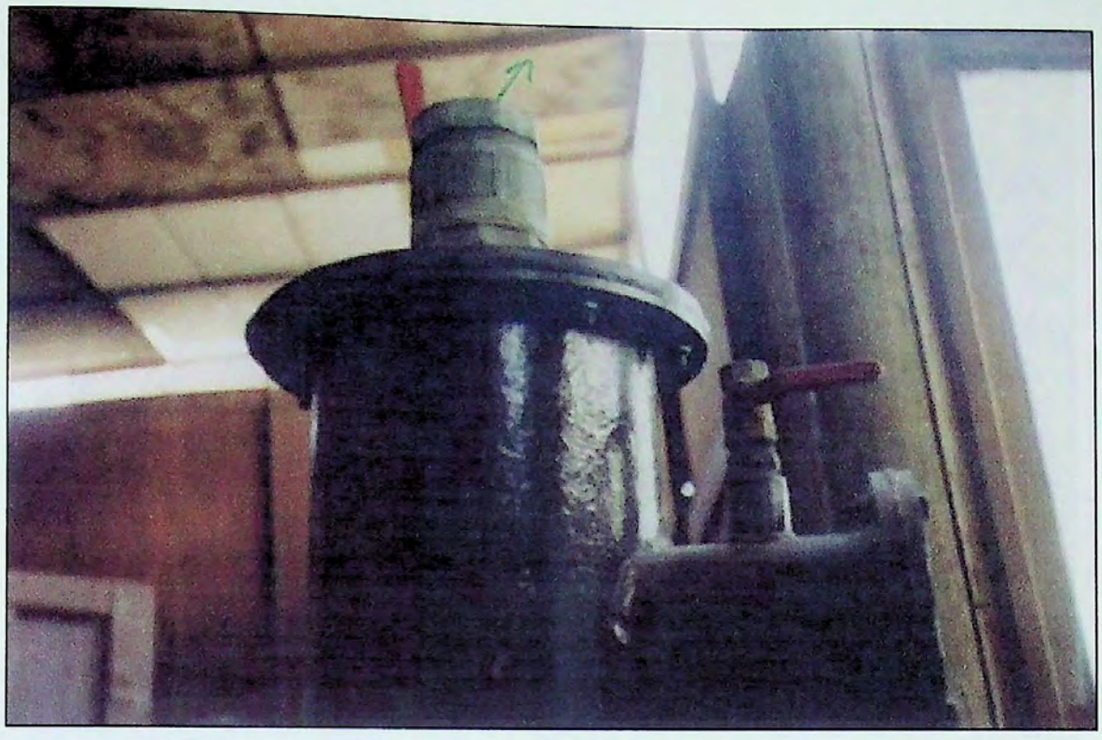


Fig. 25 : C) The inlet of the water with the snails

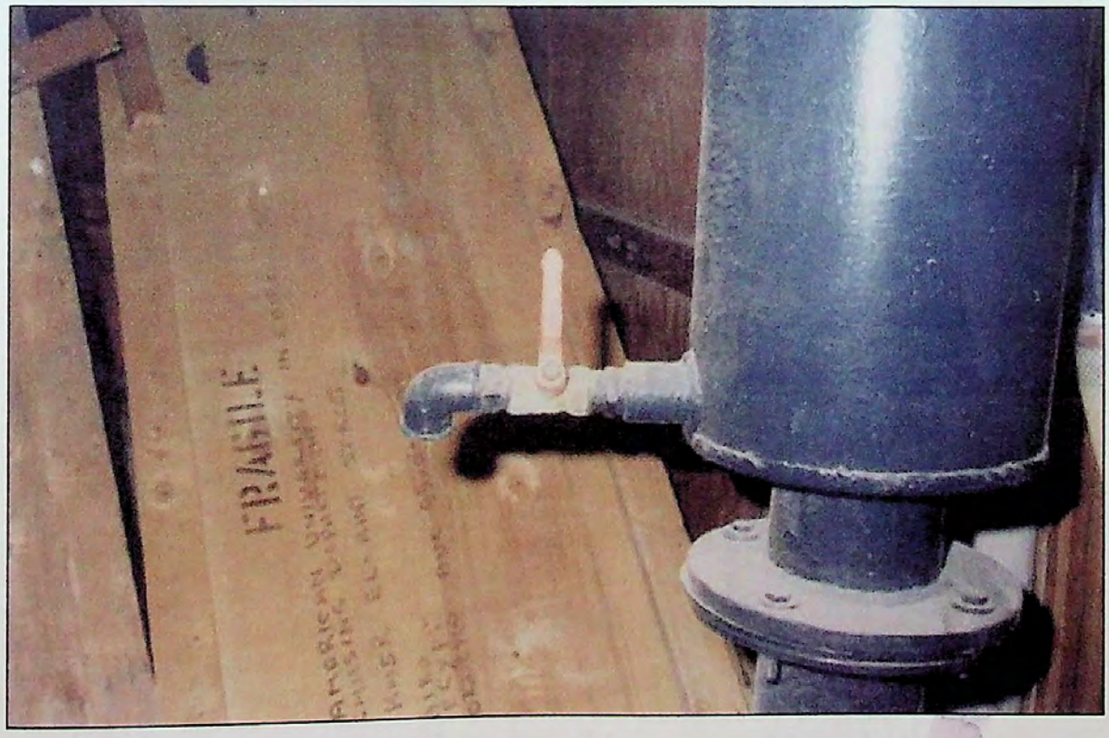


Fig. 25 : D) Outlet "A" of the clean water

Fig. 25 : E) Pump to circulate the flow

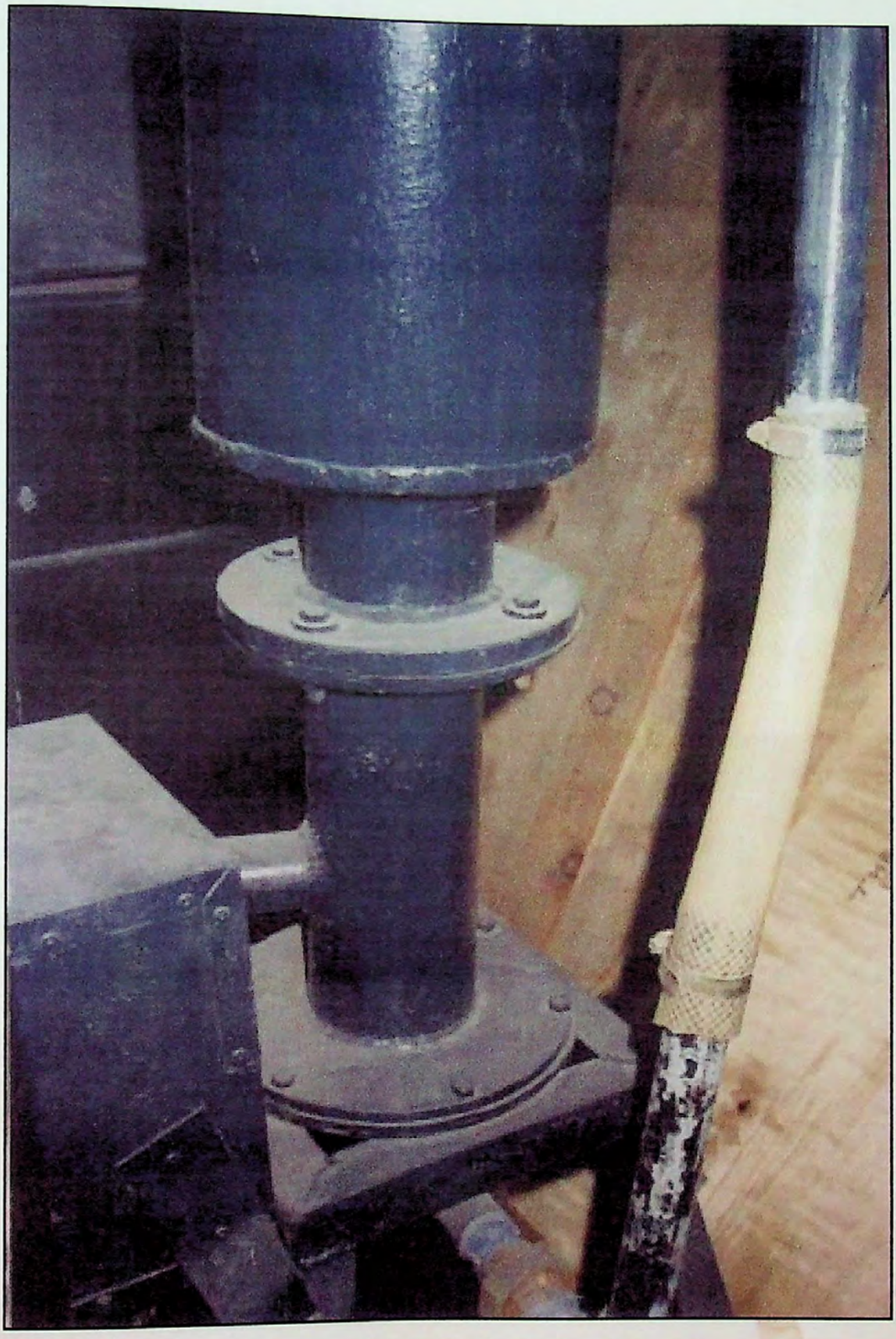


Fig. 25 : F) Gear box connection with the apparatus

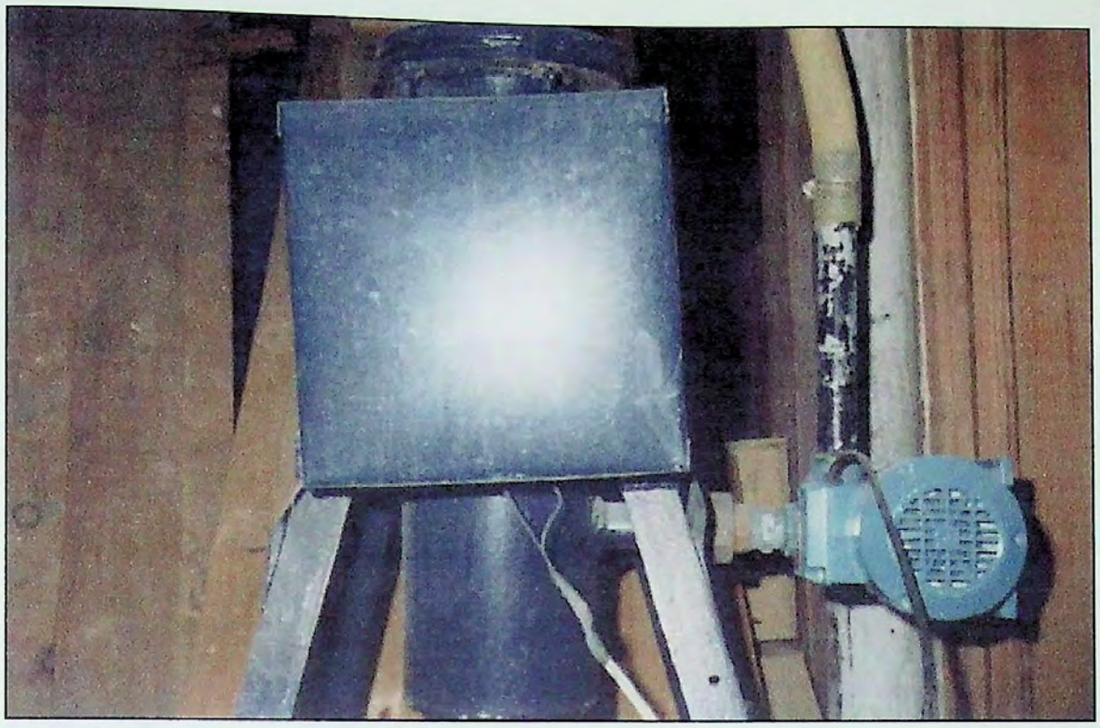


Fig. 25 : G) Gear box with the horizontal and vertical gears in it (front)

Fig. 25 : H) Gear box with the horizontal and vertical gears in it (side)

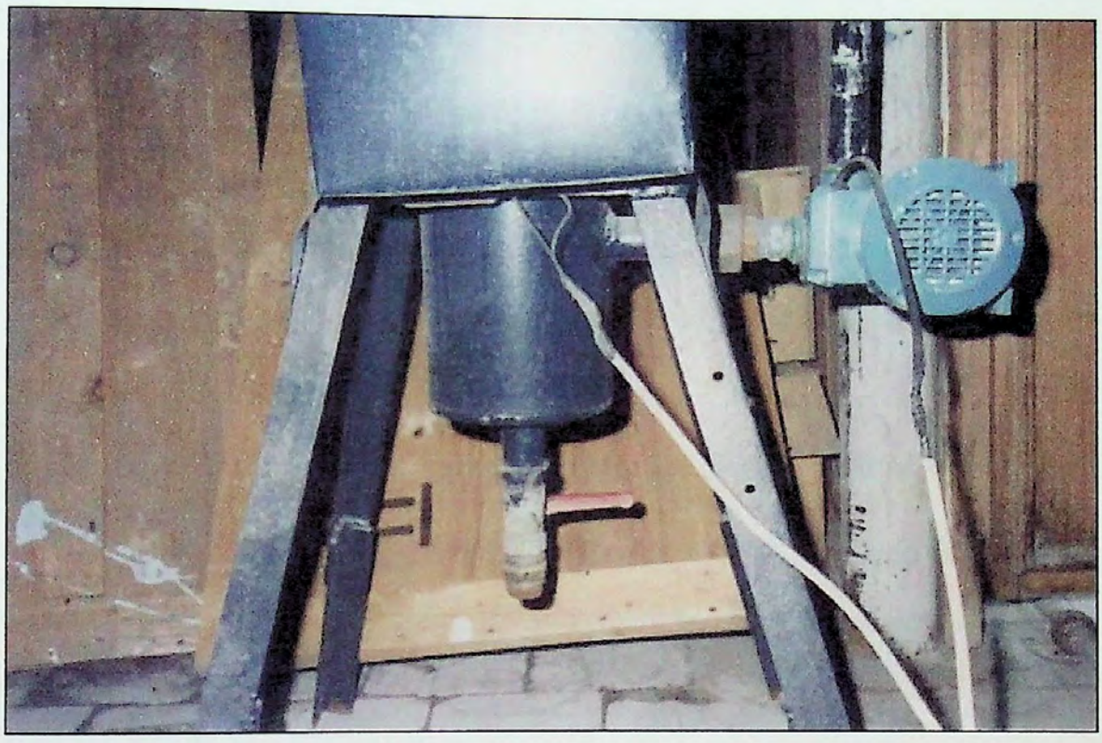


Fig. 25 : I) Outlet "B" -water with snails and fine debris-

Chapter (4)

EXPERIMENTAL PROCEDURE AND RESULTS

4.1-Swirling apparatus

The effect of the swirling motion on the percentage kill of the snails is examined and discussed in the following section. Swirlers of different blade angle, sizes, and configurations are investigated.

4.1.1- Effect of the swirling angle on the percentage kill of the snails

Swirlers with different blade angles of 15, 30°, 45° and 60° are used in order to decide which one will result in the highest percentage kill of the snails.

4.1.1.1- Procedures of the experiment

In order to carry out the experiments, the following procedures were done:

1 Tap water is filled in a container and left for 24 hours in the sun and open air, in order to be sure that all the chlorine is evaporated. This is so because the snails have to live in non-chlorinated water.

2- The snails are placed in a beaker with non-chlorinated water and preserved under a temperature of about 20° c.

3- Install the 10 cm diameter swirler in the holder .(Fig. 26)

4- Before starting to run any of the experiments , the apparatus is cleaned every time; this is done as follows:

- Open valve "A" to let the water enter into the apparatus. At the same time open valves "B" and "C" and close valve "D".
- Once the apparatus is filled by water , close valve "A".
- Switch on the pump and let the water circulate for about five minutes.
- Switch off the pump while opening valve "D" in order to empty the apparatus from the water.
- Repeat those -cleaning- steps several times until being sure that the apparatus is completely cleaned.

5- Close valves "A" and "D" and fill the non-chlorinated water from entrance "E".

6- After filling the apparatus with the non-chlorinated water, put the snails also from "E" .

7- Switch the pump on and take the reading of the flowmeter.

8- Let the snails circulate for five minutes and then shut down the pump and take the reading of the flowmeter.

9 Empty the apparatus by opening valve "D". A very fine sieve is put at the outlet to receive the snails that are coming out of the experiment on it.

1 - Fill the apparatus with non-chlorinated water again and empty it. Repeat this for several times until no snails are received on the sieve.

11- Count the snails that are alive in order to calculate the percentage kill. And examine the snails under the microscope.

12 Repeat steps 1 to 10 using different swirlers with different angles (15°, 30°, 45° and 60°) as shown in Figure (27).

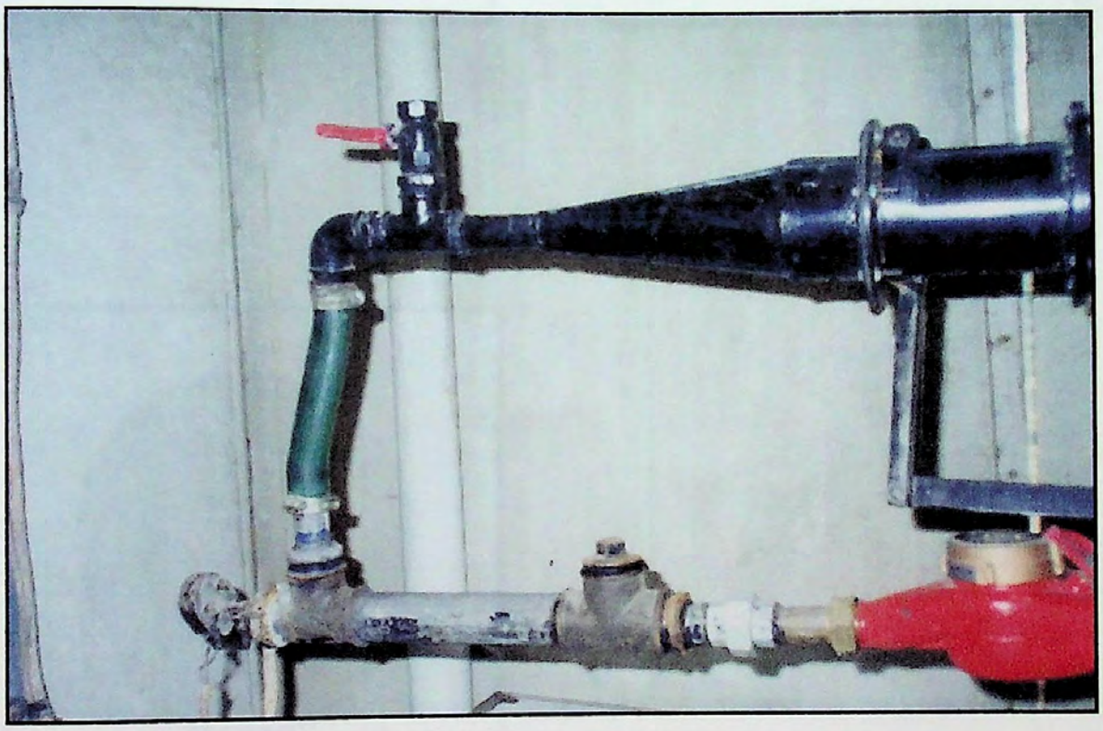


Fig. 26 : Holder of the 10 cm diameter swirlers

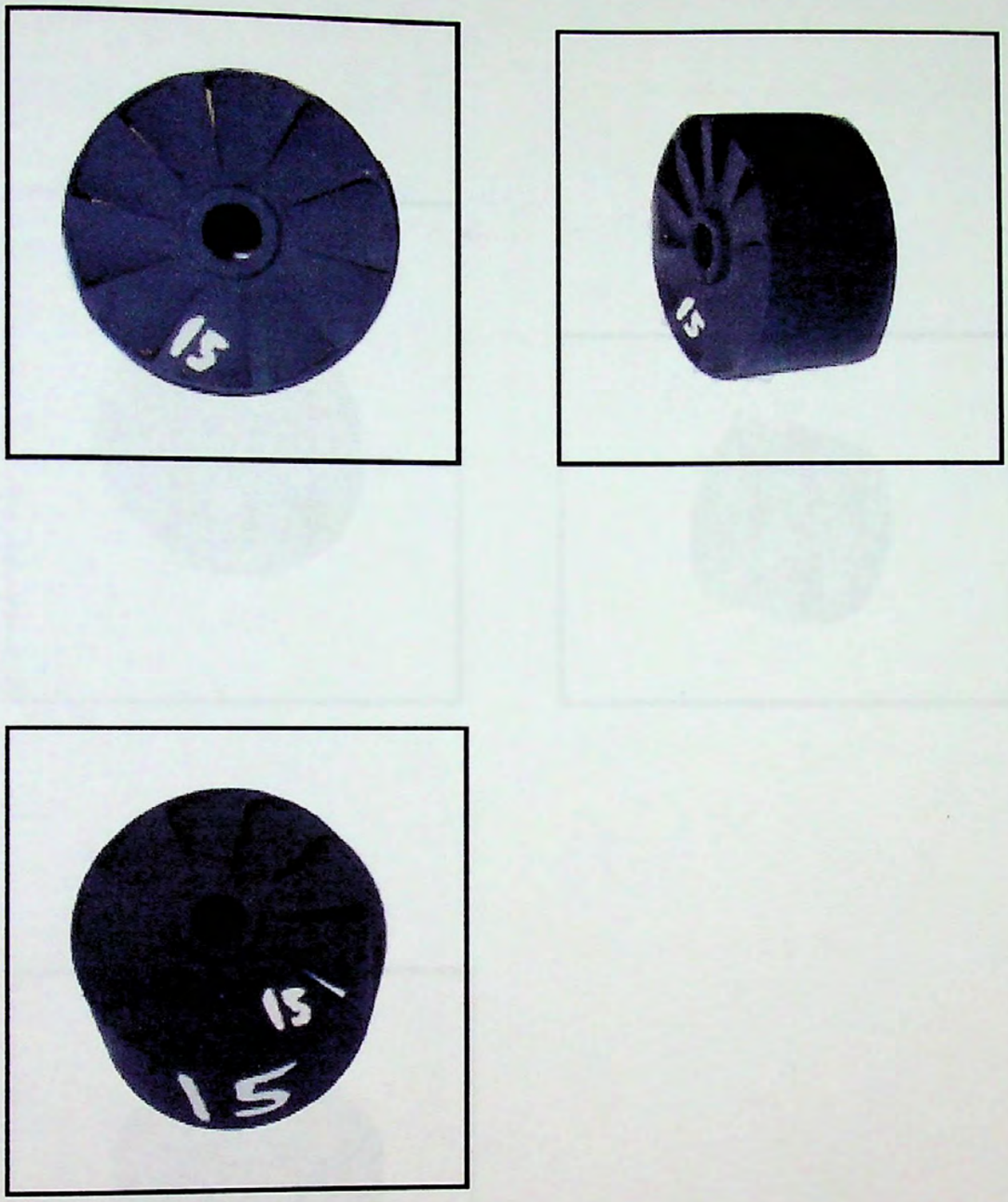


Fig. 27 : A) 15 degrees swirler with different views

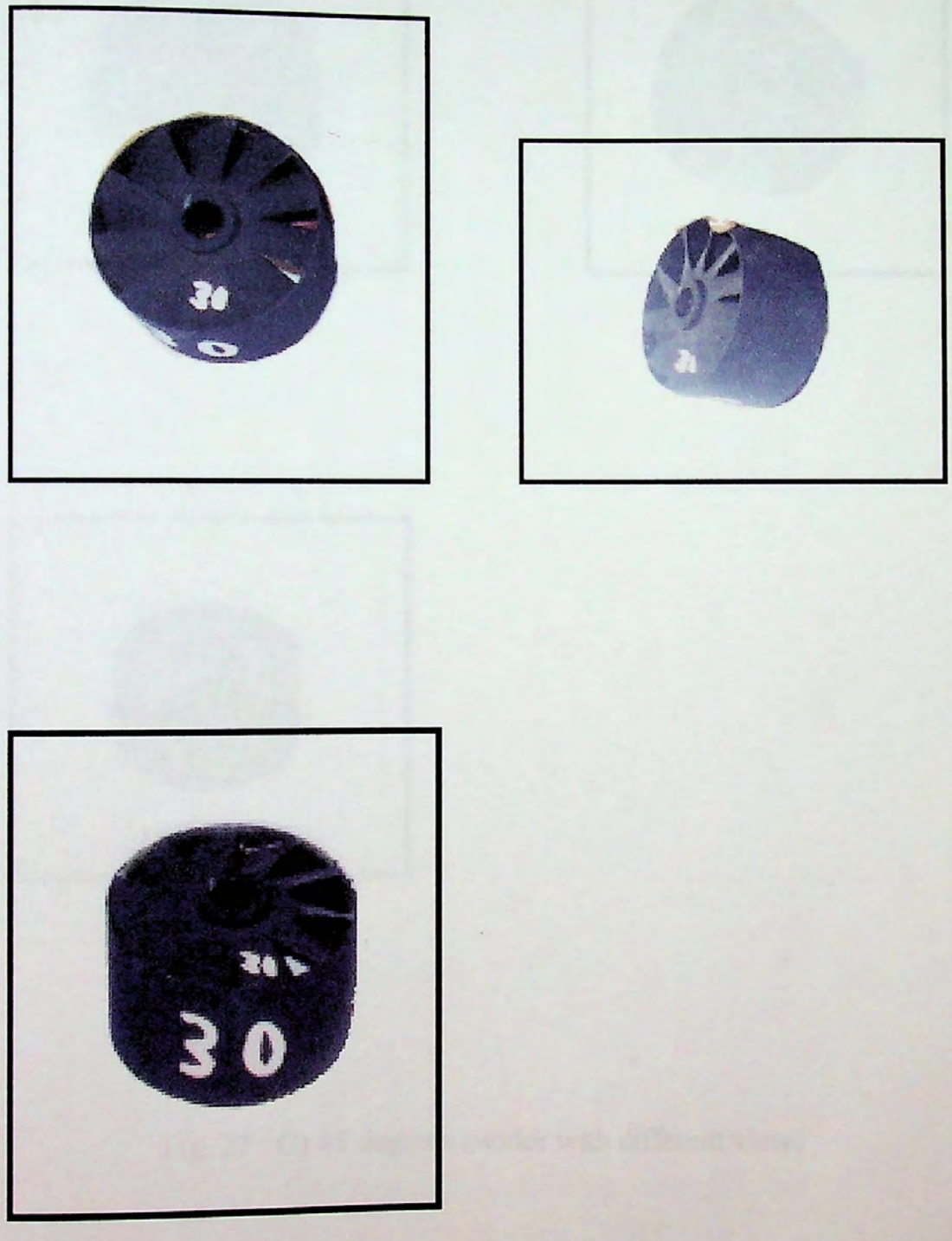


Fig. 27 : B) 30 degrees swirler with different views

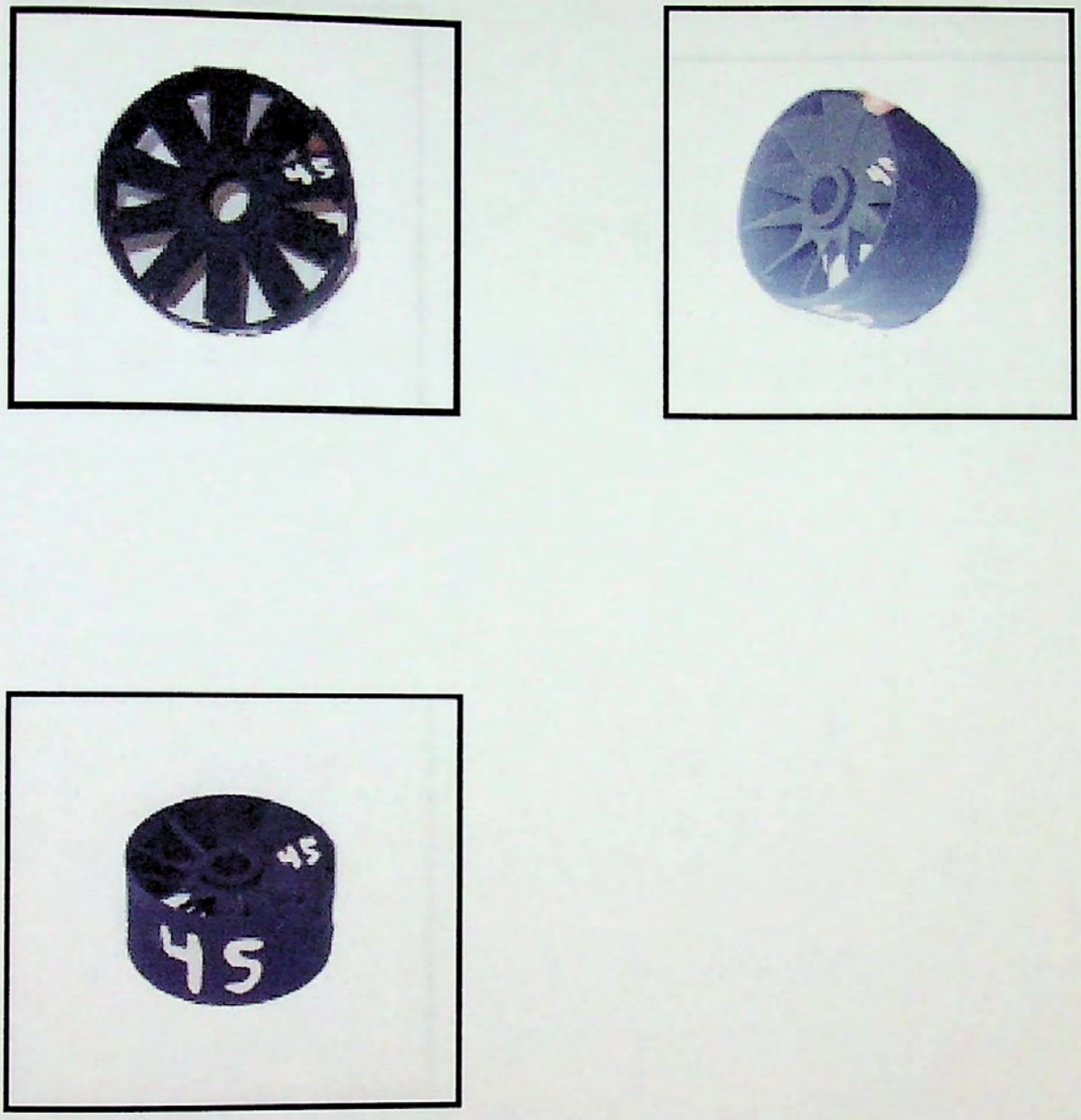


Fig. 27 : C) 45 degrees swirler with different views

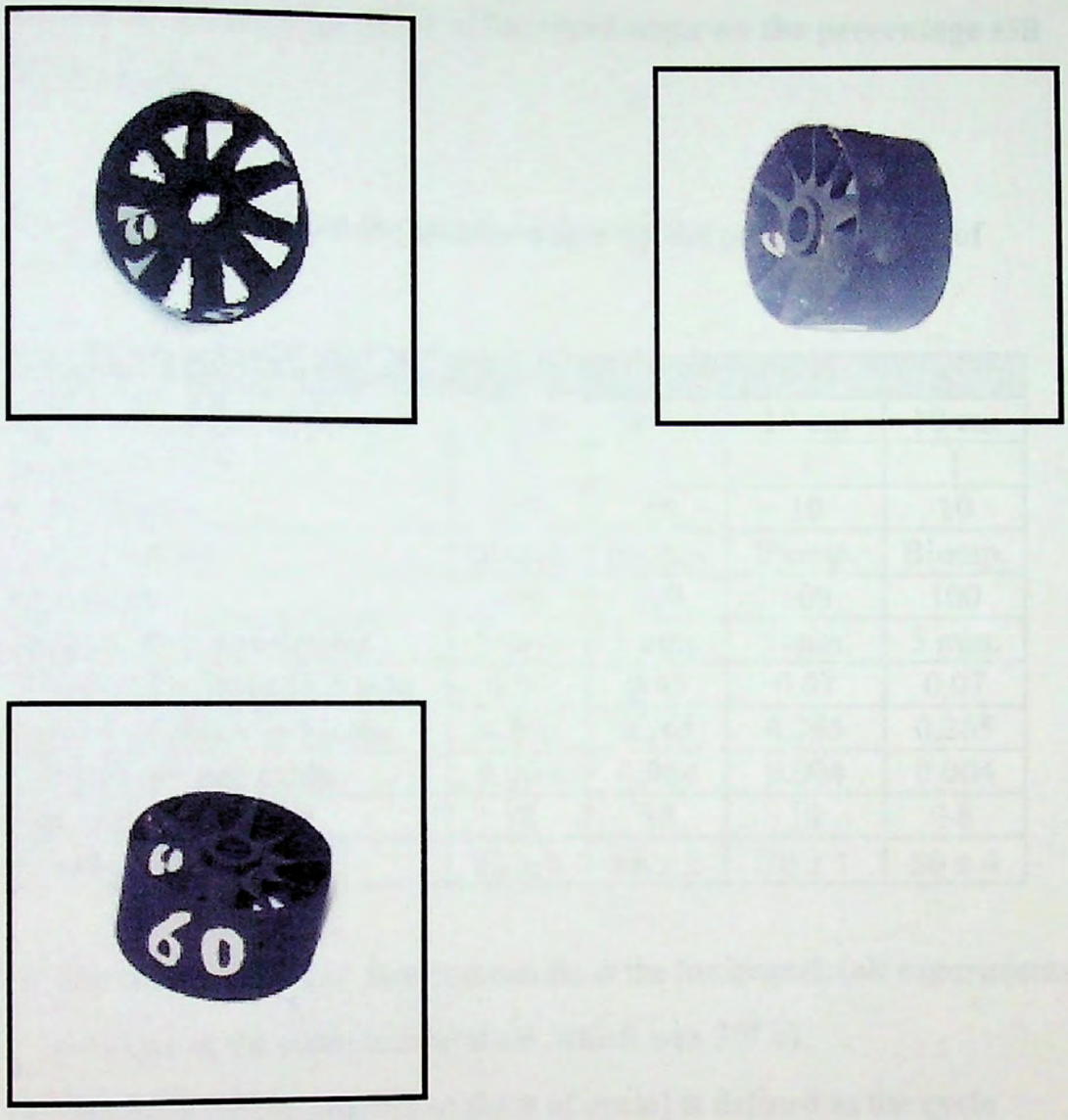


Fig. 27 : D) 60 degrees swirler with different views

4.1.1.2- Results of the effect of the swirl angle on the percentage kill of the snails

Table 4.1 a : Effect of the swirler angle on the percentage kill of snails

Angle of swirler in degrees	15	30	45	60
Diameter of the swirler	10 cm	10 cm	10 cm	10 cm
Diameter ratio	1	1	1	1
# of blades	10	10	10	10
Type of snails	Biomp.	Biomp.	Biomp.	Biomp.
# of snails	100	100	100	100
Time of the experiment	5 min.	5 min.	5 min.	5 min.
Total # of gallons in 5 min.	0.07	0.07	0.07	0.07
Total # of liters in 5 min.	0.265	0.265	0.265	0.265
# of gallons per cycle	0.004	0.004	0.004	0.004
# of cycles in 5 min.	18	18	18	18
% kill of snails	92 ± 1	88 ± 2	70 ± 1	50 ± 4

- The swirling angle is measured from the horizontal. (all experiments are done at the room temperature ,which was 30° c).
- The cycle (in the column of the # of cycle) is defined as the cycle taken from a snail to circulate one time from one point through the whole apparatus to the same point again.
- Diameter ratio = swirler diameter/transparent tube diameter

After conducting the first experiment, it is worth to do a Background experiment, where no swirlers are used. This is in order to compare the results so as to see if the swirlers do an effect on the percentage kill of the snails or not

Table 4.1 b : Effect of the swirler angle on the percentage kill of snails

Type of snails	Biomp.
# of snails	100
Time of the experiment	5 min.
Total # of gallons in 5 min.	0.07
Total # of liters in 5 min.	0.265
# of gallons per cycle	0.004
# of cycles in 5 min.	18
% kill of snails	15 ± 2

4.1.1.3- Observations

Upon conducting the previously listed experiments, the following observations were made :

1- The smaller swirling angles killed more snails (the best killing swirler is that of the angle 15°.

2- It could be noted that by smaller swirling angle the small crushed pieces of snails were more than at large angles.

3- Settling of snails on the bottom of the glass tube of the experiment instrument could be observed to happen only at the swirler with angle 60°.

4- The swirlers with the small angles yielded more turbulence in water than the other swirlers.

5 It was also observed that some of the shells appeared transparent in color to the eye (original color is black).

6- When examining the snails under the microscope it could be observed that the transparent shells are of snails that were killed and had broken shells. The transparent color came from the fact that the animal left the shell upon its breakage and thus the shell is hollow. The breakage is either like a hole in the body of the shell or it is that plus small breakages (like teeth bites) at the outer ends of the shell.(Fig. 28)

7- The background experiment yielded a percentage kill that is much lower (15%) than if the swirlers are used. The swirler with angle of 60 degrees which yielded the lowest percentage kill,50%, among the swirlers has a much higher percentage kill associated with it than the background experiment.

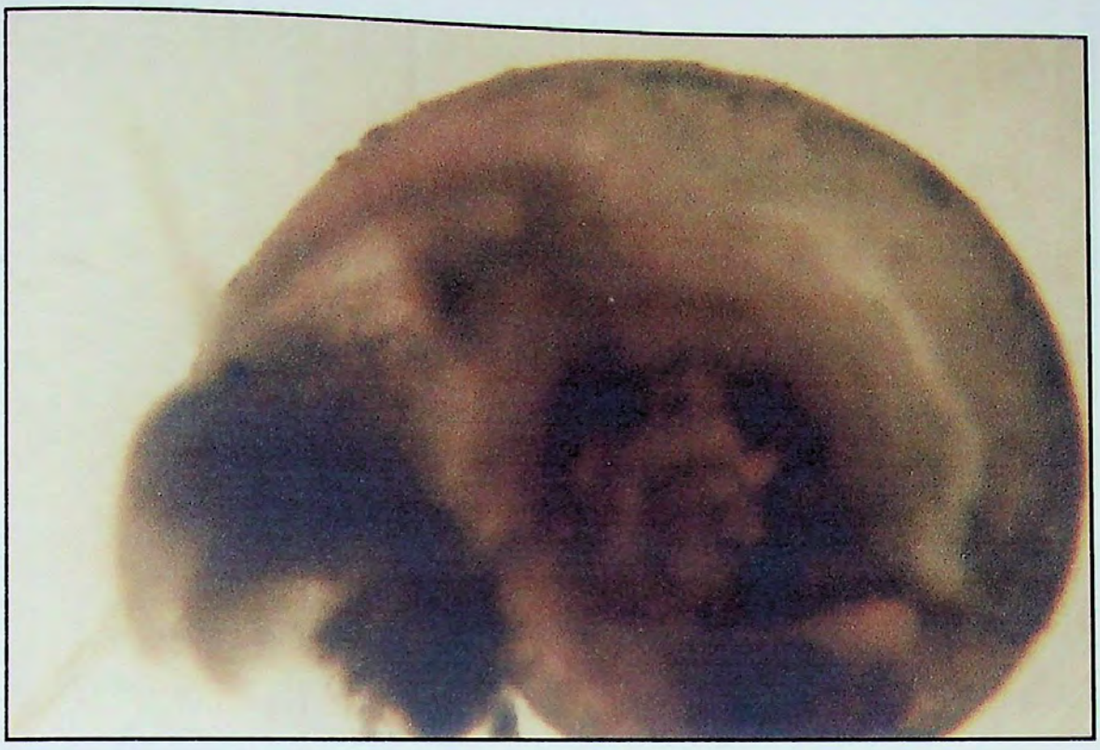


Fig. 28 : A) A Biomphalaria Alexandrina living snail -whole snail-

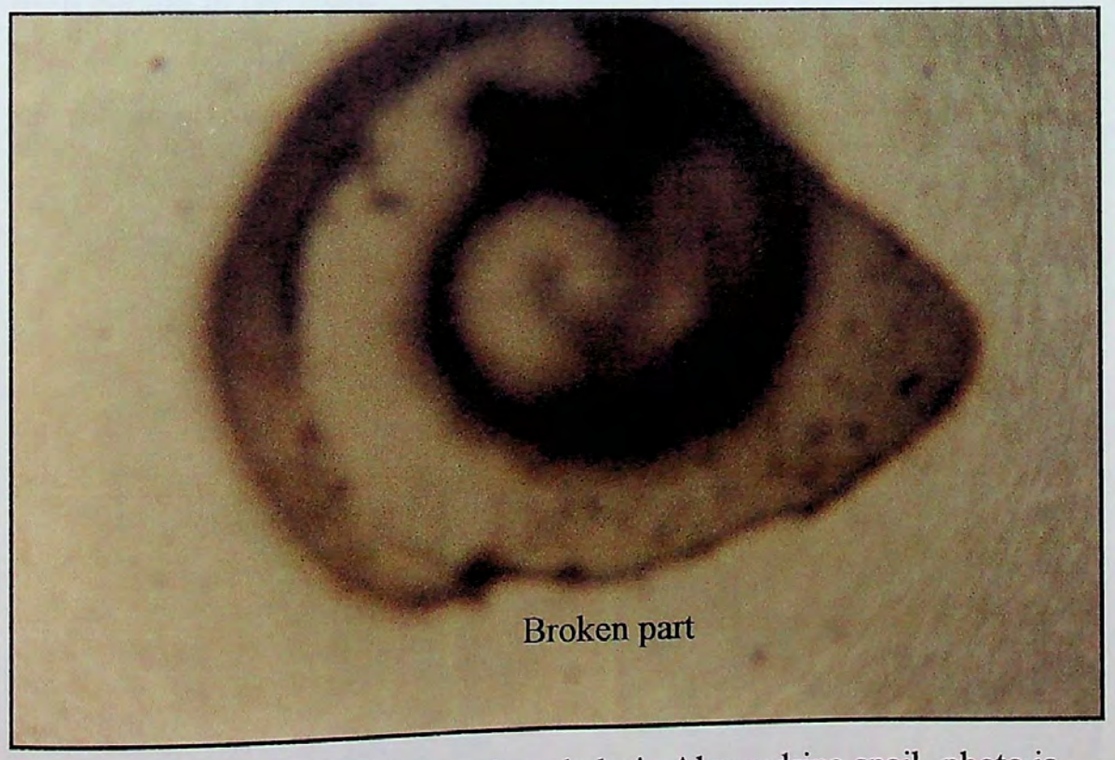


Fig. 28 : B) A broken shell of Biomphalaria Alexandrina snail -photo is from the bottom of the snail-

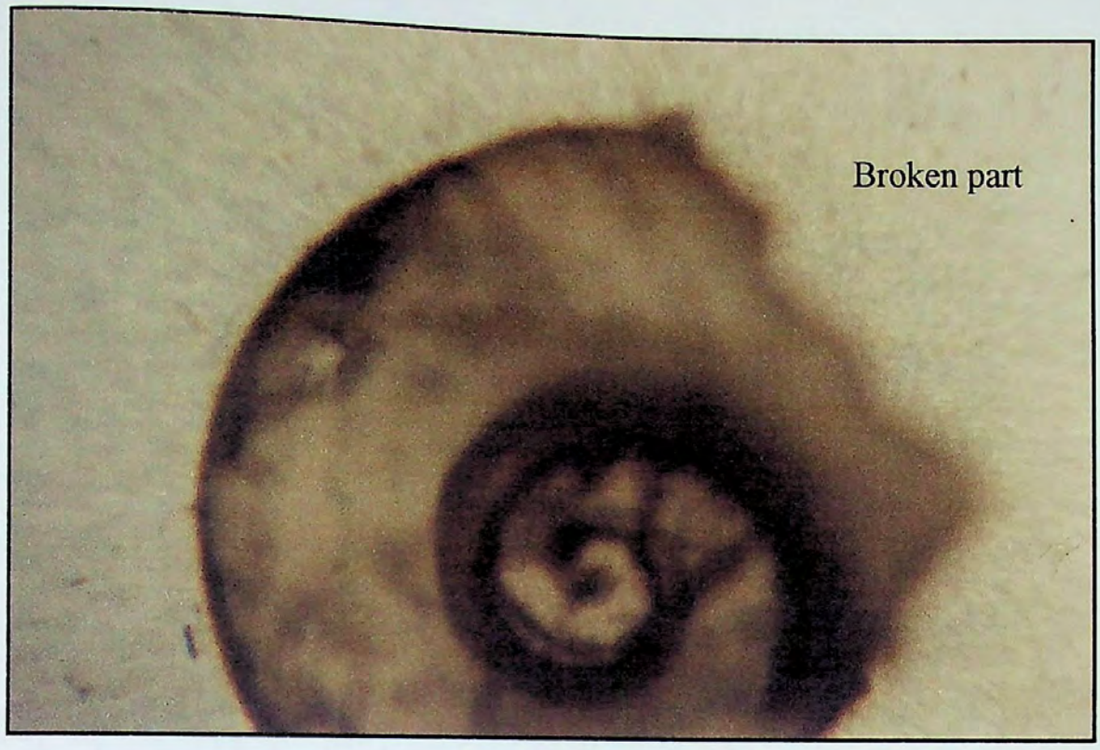


Fig. 28 : C) A broken shell of Biomphalaria Alexandrina snail -photo is from the top of the snail-

Fig. 28 : D) A broken shell of Biomphalaria Alexandrina snail -photo is from the bottom of the snail-

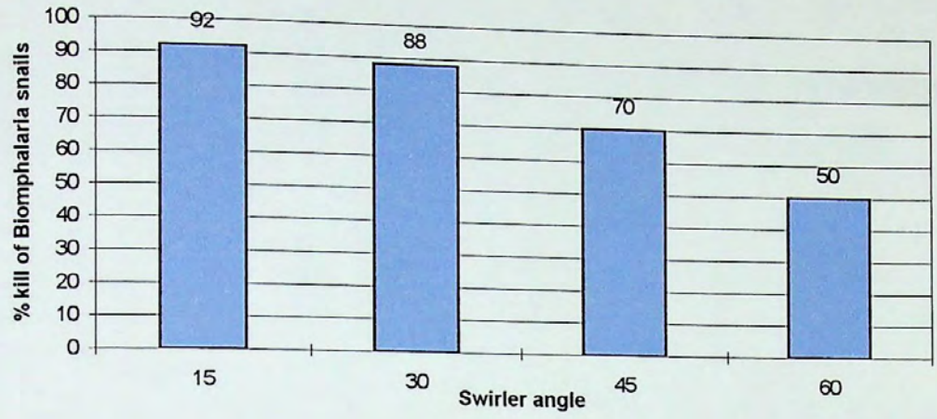


Fig. 29 : Effect of the swirling angle on the percentage kill of the Biomphalaria snails(bar chart)

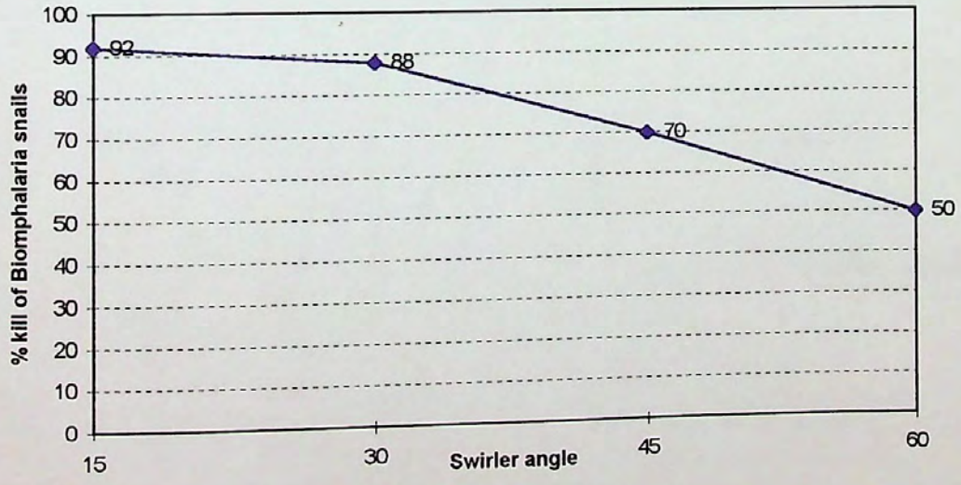


Fig. 30 : Effect of the swirling angle on the percentage kill of the Biomphalaria snails (curve)

4.1.2-Effect of the temperature on the percentage kill of the snails

The following experiment is conducted in order to examine the effects of raising the temperature on the snails percentage kill.

4.1.2.1-Procedures of the experiment

In order to carry out this experiment, the procedures of the previous experiment were followed, but added to them are the following steps:

1- After filling the apparatus with the non-chlorinated water, switch on the heater.

2- Put a thermometer at the entrance "E".

3- The heater will raise the temperature of the water gradually .

4- Keep checking the temperature rise on the thermometer until the desired temperature is reached (50° c).

5- When the desired temperature is reached, switch off the heater.

6- The snails are now allowed to enter from the entrance "E".

7- Switch the pump on and take the reading of the flowmeter.

8- Let the snails circulate for five minutes and then shut down the pump and take the reading of the flowmeter.

9- Empty the apparatus by opening valve "D". A very fine sieve is put at the outlet to receive the snails that are coming out of the experiment on it.

1 - Fill the apparatus with non-chlorinated water again and empty it. Repeat this for several times until no snails are received on the sieve.

11- Count the snails that are alive in order to calculate the percentage kill. As said before the living snails appear dark brown or black to the eye, whereas, the killed snails appear transparent in color to the eye. After that examine the snails under the microscope.

12 All the steps are repeated but by operating on a 30 and 45 degrees swirlers.

4.1.2.2- Results of the effect of the temperature on the percentage kill of the snails

Table 4.2 : Effect of the temperature on the percentage kill of the snails

Angle of swirler in degrees	15	30	45
Temperature in ° c	50	50	50
Diameter of the swirler	10 cm	10 cm	10 cm
Diameter ratio	1	1	1
# of blades	10	10	10
Type of snails	Biomp.	Biomp.	Biomp.
# of snail	100	100	100
Time of the experiment	5 min.	5 min.	5 min.
Total # of gallons in 5 min.	0.07	0.07	0.07
Total # of liters in 5 min.	0.265	0.265	0.265
# of gallons per cycle	0.004	0.004	0.004
# of cycles in 5 min.	18	18	18
% kill of snails	93 ± 2	88 ± 1	72 ± 2

- The swirling angle is measured from the horizontal.
- Diameter ratio = swirler diameter/transparent tube diameter

4.1.2.3- Observation

It was observed that raising the temperature had a minor effect on the percentage kill of the snails. The percentage kill of snails when raising the temperature for 20 degrees above the room temperature increased only by approximately two percent.

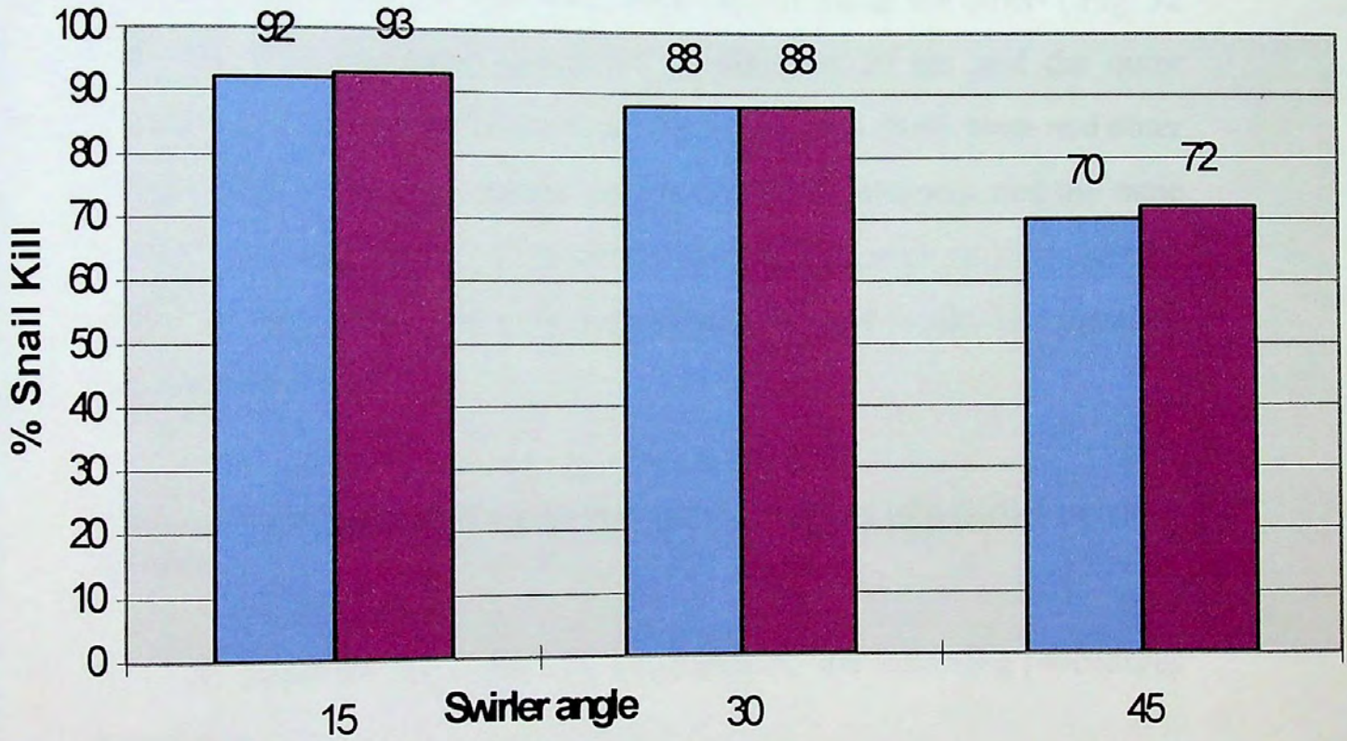


Fig. 31 : Effects of the temperature rise on the percentage kill of the Biomphalaria snails

4.1.3- Effect of the swirler's geometry on the percentage kill of the snails

The following two experiments deal with the examination of the changing the geometry of the swirlers on the percentage kill of the snails. In the first experiment, swirlers constructed in parallel will be placed in the -for this purpose constructed- holder. Parallel means that there are two swirlers concentric with each other - one is inside the other- (Fig. 32 and Fig. 33). The inner swirler is of diameter 10 cm and the outer diameter of the whole parallel set-up is 15 cm. Both inner and outer swirlers have the same blades' angle, which is 15 degrees, and the same blades number, which is 10 blades. The second experiment examines the effect of the change in the swirler's diameter on the snails. The diameter examined is 6 cm.

4.1.3.1- Procedures of the experiment of the effect of parallel swirlers set-up

In order to carry out the experiments, the following procedures were done:

1 Tap water is filled in a container and left for 24 hours in the sun and open air, in order to be sure that all the chlorine is evaporated. This is so because the snails have to live in non-chlorinated water.

2- The snails are placed in a beaker with non-chlorinated water and preserved under a temperature of about 20 °c.

3- Replace the holder in which the 10 cm diameter swirler was placed with another larger holder in order to install into it the two concentric parallel swirlers. The inner swirler is still of a diameter 10 cm , the whole parallel setup is 15 cm in diameter, and both the outer and inner swirlers are of angle 15° .(Fig 32 & Fig. 33)

4- Before starting to run any of the experiments , the apparatus is every time cleaned ; this is done as follows:

- Open valve "A" to let the water enter into the apparatus. At the same time open valves "B" and "C" and close valve "D".
- Once the apparatus is filled by water , close valve "A".
- Switch on the pump and let the water circulate for about five minutes.
- Switch off the pump while opening valve "D" in order to empty the apparatus from the water.(let the "A" valve and the valve "D" be opened at the same time- conservation of mass- for a while to ensure the washing of the apparatus and then close valve "A" and let valve "D" remain opened .)
- Repeat those -cleaning- steps several times until being sure that the apparatus is completely cleaned.

5- Close valves "A" and "D" and fill the non-chlorinated water from entrance "E".

6- After filling the apparatus with the non-chlorinated water, put the snails also from "E" .

7- Switch the pump on and take the reading of the flowmeter.

8 Let the snails circulate for five minutes and then shut down the pump and take the reading of the flowmeter.

9- Empty the apparatus by opening valve "D". A very fine sieve is put at the outlet to receive the snails that are coming out of the experiment on it.

10- Fill the apparatus with non-chlorinated water again and empty it. Repeat this for several times until no snails are received on the sieve.

11- Count the snails that are alive in order to calculate the percentage kill. And examine the snails under the microscope.

Fig. 32 : The holder of the parallel configuration

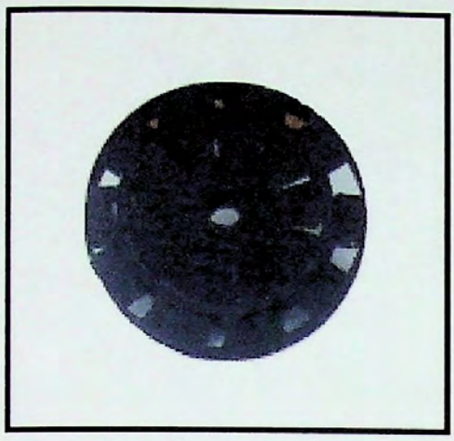


Fig. 33 : A) Different views of the parallel swirler

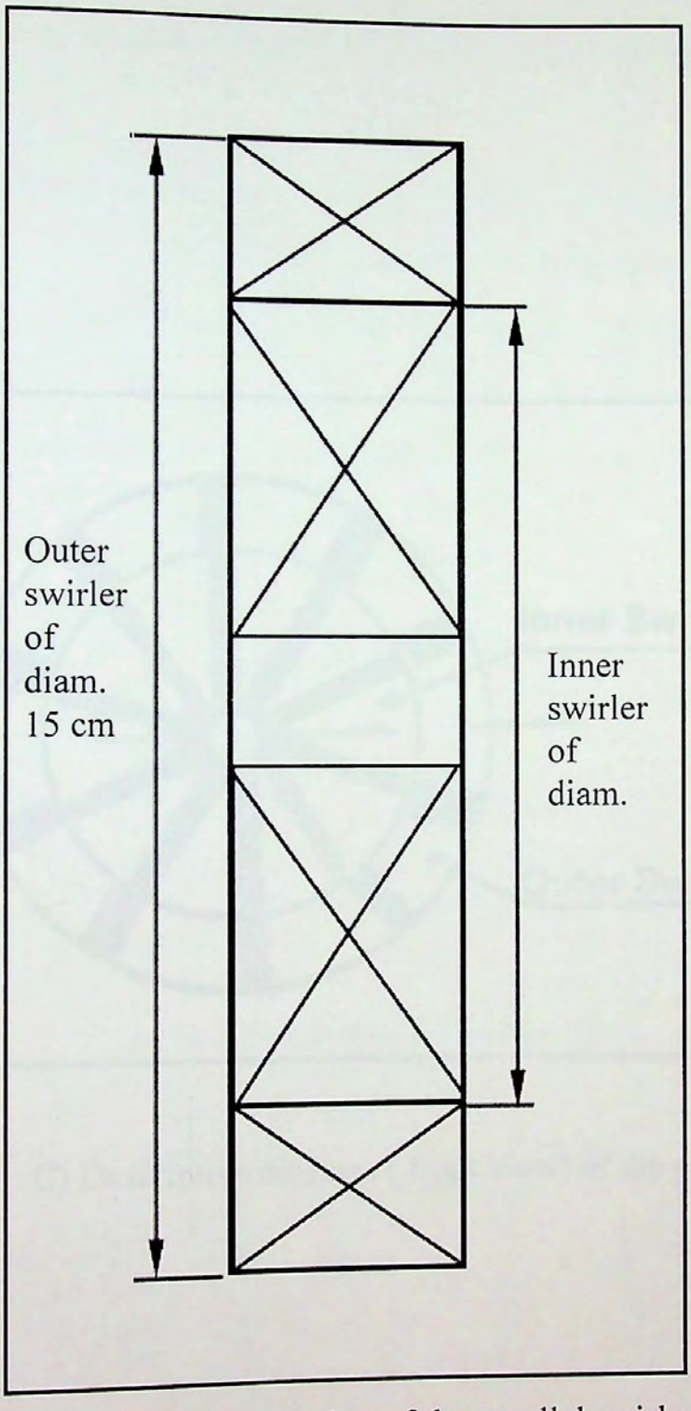


Fig. 33 : B) Cross section of the parallel swirler

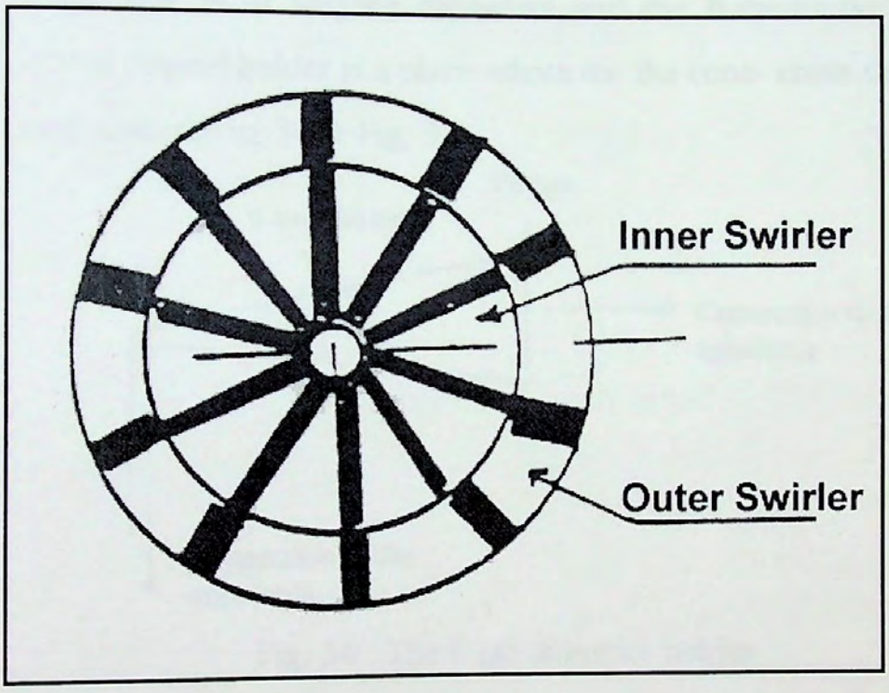


Fig. 33 : C) Descriptive diagram (front view) of the parallel swirler

4.1.3.2- Procedures of the small swirler (6cm diameter) experiment:

The procedures are the same as by the experiment of the parallel swirlers but the only difference is that here the large holder in which the parallel swirlers were located will be removed and replaced by a conical shape holder that is of varying diameters and the 6 cm swirler will be placed in that conical holder at a place where its- the cone- cross section is of a 6 cm diameter.(Fig. 34 & Fig. 35)

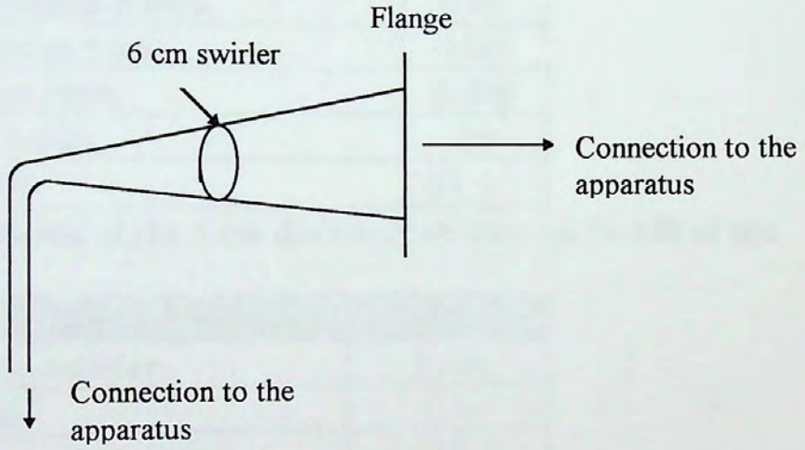


Fig. 34 : The 6 cm diameter holder

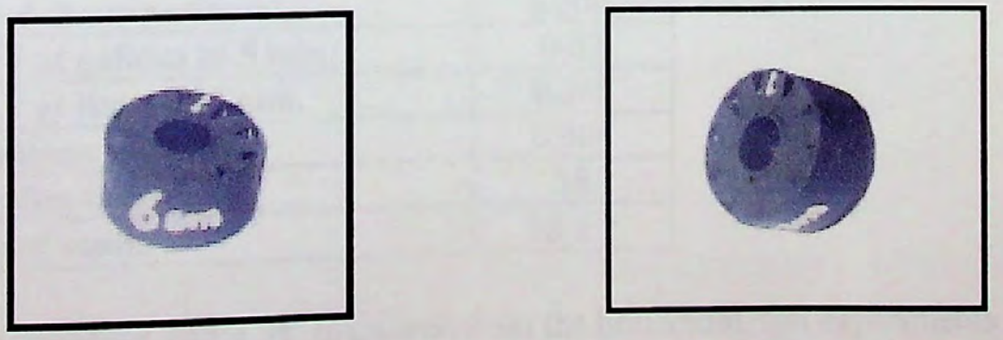


Fig. 35: The 6 cm diameter swirler (with 15 degrees angle)

4.1.3.3- Results of the effect of the swirler's configurations and sizes on the percentage kill of the snails

Table 4.4 : Effect of the parallel swirlers on the % kill of the snails

Angle of the inner swirler in degrees	15
Angle of swirler in degrees	15
Diameter of the inner swirler	10 cm
Diameter of the outer swirler	15 cm
Diameter ratio	1.5
# of blades (inner = outer swirler)	10
Type of snails	Biomp.
# of snail	100
Time of the experiment	5 min.
Total # of gallons in 5 min.	0.07
Total # of liters in 5 min.	0.265
# of gallons per cycle	0.004
# of cycles in 5 min.	18
% kill of snails	94 ± 1

Table 4.5 : Results of the 6 cm diameter swirler on % kill of the snails

Angle of swirler in degrees	**15**
Diameter of the swirler	6 cm
Diameter ratio	0.6
# of blades	10
Type of snails	Biomp.
# of snail	100
Time of the experiment	5 min.
Total # of gallons in 5 min.	0.07
Total # of liters in 5 min.	0.265
# of gallons per cycle	0.004
# of cycles in 5 min.	18
% kill of snails	98 ± 2

- the swirling angle is measured from the horizontal. (all experiments are done at the room temperature ,which was 30° c).
- Diameter ratio = swirler diameter/transparent tube diameter.

4.1.3.4- Observation

It was observed in this experiment that the two concentric or parallel swirlers killed 1% more snails than the single swirler which is of the same angle.

It is also observed that the 6 cm diameter swirler has a very high percentage kill associated with it. It could also be observed that this swirler increases the turbulence.

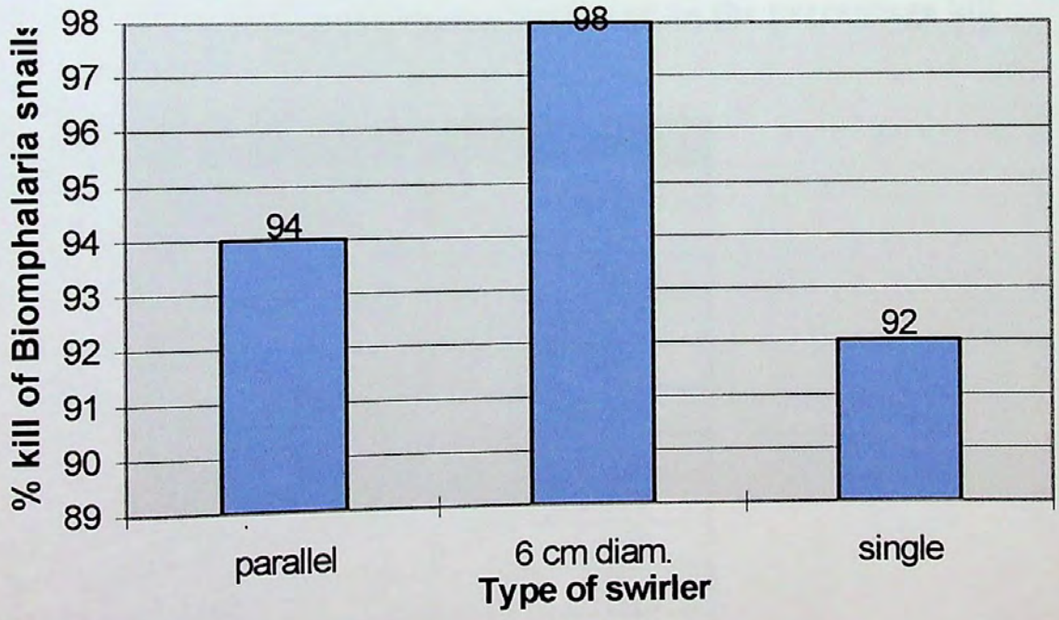


Fig. 36 : Comparison between different sizes and configurations of the swirlers

4.1.4- Effect of the low discharge on the percentage kill of the Biomphalaria snails

The procedures of this experiment is exactly the same procedures of the first experiment (4.1.1.1) but here the discharge or the volume flow rate is decreased.

4.1.4.1-Results of the experiment

Table 4.6 : Effect of decreasing the discharge on the percentage kill of the snails

Angle of swirler in degrees	15
Diameter of the swirler	10 cm
Diameter ratio	1
# of blades	10
Type of snails	Biomp.
# of snail	100
Time of the experiment	5 min.
Total # of gallons in 5 min.	0.02
Total # of liters in 5 min.	0.076
# of gallons per cycle	0.003
# of cycles in 5 min.	7
% kill of snails	70 ± 2

4.1.4.2- Observations

It was observed that decreasing the volume flow rate decreases the percentage kill of snails. This is due to the low discharge where the velocity decreases (because the area is constant) and thus the snails are not killed easily since the snails can tolerate this decrease in velocities.

It was also noticed that while conducting this experiment , the snails were always settling on the bed of the transparent tube; this is again because of the low velocity of the flow.

4.1.5- Effect of the swirling motion on the Bulinus strain of the snails

As mentioned before this thesis deals with the two types of the Schistosomiasis snails found in Egypt; namely Biomphalaria Alexandrina and Bulinus Trancatus. All the previously mentioned experiments were conducted on the Biomphalaria type. The following experiment; on the other hand, is conducted to examine the effect of the 15 degrees angle swirler on the Bulinus ginus of the snails.

4.1.5.1- Procedures of the experiment

In order to carry out this experiment, the procedures of experiment number one are repeated except for the following:

1- The snails used are of the type, Bullinus Trancatus instead of Biomphalaria Alexandrina.(Fig. 37)

2- The experiment was done using the 10 cm diameter swirler with 15 degrees blade angle.

Fig. 37 : A) The Bulinus Trancatus snails - under the microscope- the whole snail alive

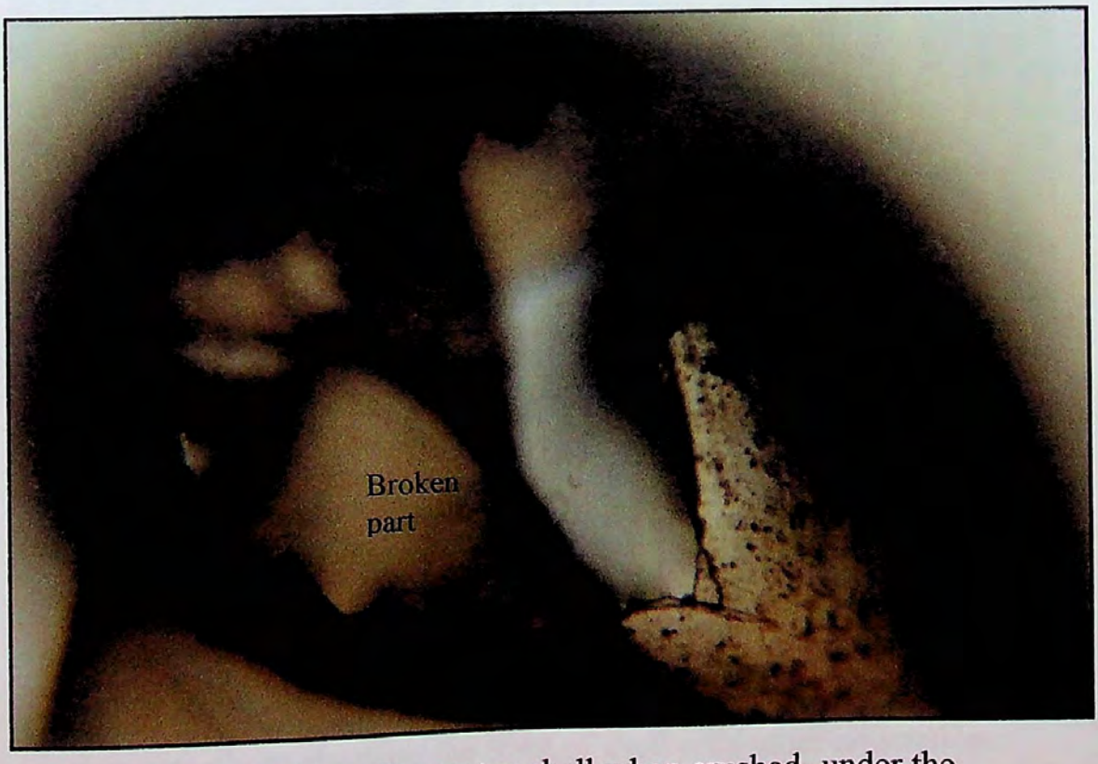


Fig. 37 : B) The Bulinus Trancatus shell when crushed- under the microscope- photo showing the front of shell-.

Fig. 37 : C) The Bulinus Trancatus shell when crushed- under the microscope- photo showing the front of shell with other orientation.

Fig. 37 : D) Another Bulinus Trancatus shell when crushed- under the microscope- photo taken at the front of the shell-.

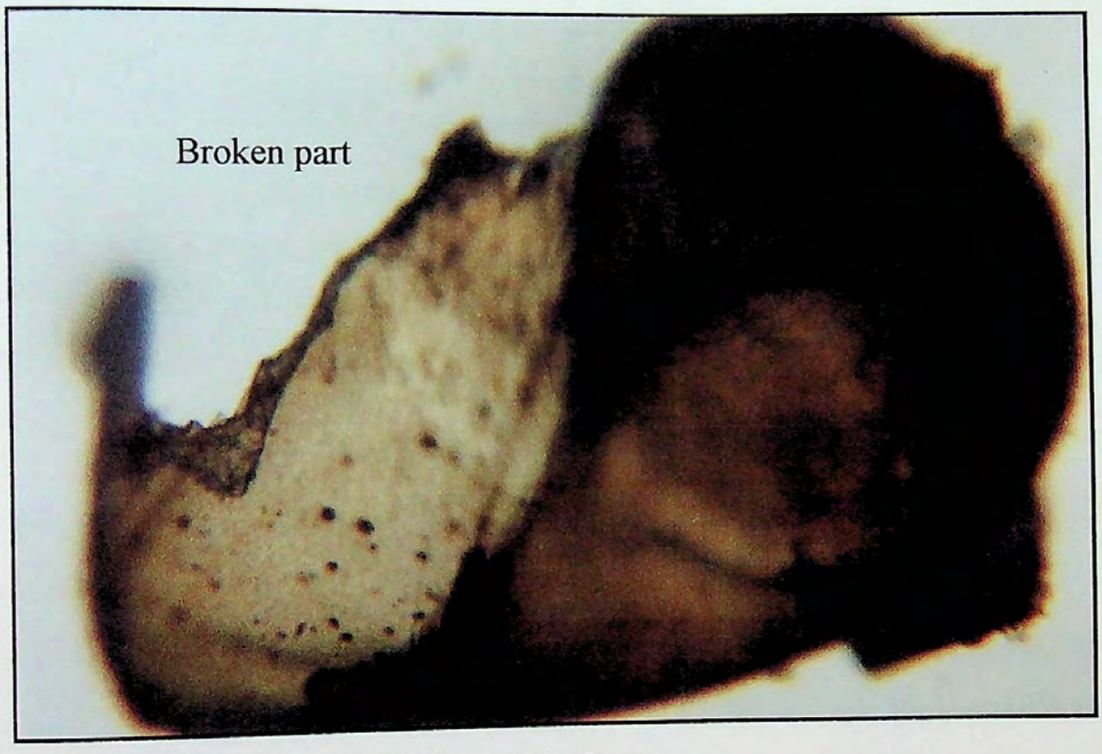


Fig. 37 : E) Another orientation of the front.

4.1.5.2- Results of the experiment

Table 4.7 : Effect of the swirling motion on the Bulinus strain of the snails

Angle of swirler in degrees	15
Diameter of the swirler	10 cm
Diameter ratio	1
# of blades	10
Type of snails	Bulinus
# of snail	100
Time of the experiment	5 min.
Total # of gallons in 5 min.	0.07
Total # of liters in 5 min.	0.265
# of gallons per cycle	0.004
# of cycles in 5 min.	18
% kill of snails	70 ± 3

4.1.5.3- Observations

It is observed that by using the swirler of the angle 15 degrees the percentage kill of the Bulinus snails is much lower than the percentage kill of the Biomphalaria snails.

This is because the geometry of the shell shape of the Bulinus snail can take more stresses than the Biomphalaria shell without being broken, and that is because the Bulinus shell is observed to be flatter than the Biomphalaria ones.

4.2-Experiment of the fine screen continuous mechanical cleaning apparatus

The following experiment deals with the second apparatus , which is the fine screen continuous cleaning system.

4.2.1- Aim of the apparatus

As mentioned before this apparatus is designed and constructed in order to provide a sound mechanical system to collect the baby snails using the finest screen that will be placed at the entrance of the swirling machine. This is so because the finest screen is the one that get often plugged from the baby snails. Also another purpose is to allow the smallest number of baby snails to enter the swirling apparatus and this will work as a double protection against the snails. This is so because most of the baby snails will be retained by the screen and after cleaning they will be get rid of ; whereas, the remaining number of snails that could for any reason reach the swirling apparatus will be killed there. This will ensure nearly complete eradication of the snails.

4.2.2-Procedures

The experiment is done according to the following steps:

1 Before running the experiment the apparatus should be cleaned according to the following steps:

- Water enters from the inlet and this is by opening valve "A".
- Close the outlets "B" &"A" by closing their valves.

- After that the apparatus is filled with water the pump and the brush are switched on.
- After some time-5 minutes- switch off the pump and the brush.
- Open the valve at the outlet "A" to receive the clean water and check that it is very clean and has no impurities associated with it at all.
- Open the valve at the outlet "B" in order to receive the unclean water.
- Repeat the cleaning procedures for several times to be sure that the apparatus is hundred percent clean.

2- After cleaning the apparatus, the experiment starts by opening valve "A" at the inlet and pouring the water with the snails into the apparatus.

3- Close the valves at the outlets "A" & "B".

4- Switch on the pump and the brush and let it work for 5 minutes.

5- Switch the pump and brush off.

6- Open the valve at the outlet "A" and receive the clean water.

7- Open the valve at the outlet "B" and receive the baby snails.

4.2.2- Results and discussion

After running the experiment and receiving the supposedly clean water from the outlet "A" , the water was found to be really very clean and no single baby snail was in it. The snails ; on the other hand, were received from the outlet "B". This proves that the apparatus works properly and does its needed function.

Chapter (5)

CONCLUSIONS AND RECOMMENDATIONS

5.1- Summary

As mentioned before Schistosomiasis is a very serious and dangerous disease in Egypt and most of the developing world . The disease has a life cycle in which the human being is the final host and the snail is the intermediate host. In order to prevent the disease from infecting the human being the disease cycle must be broken and this is by combating the snails. Combating snails happens through three methods, namely the chemical, biological and mechanical means. The best way to control the snails is the mechanical way, since it does not harm the environment and the living organisms.

The thesis is concerned ;therefore, with using two different mechanical systems in controlling the snails; namely the swirling motion apparatus, and the continuous fine screen cleaning system.

After conducting all the above experiments , the following could be concluded :

- As the swirl angle decreases (angle of the swirler's blades with the horizontal) the percentage kill of snail increases. The highest percentage kill (92%) was associated with the 15 degrees angle.

2- As the swirler diameter decreases, the percentage kill increases. A 6 cm diameter swirler with 15 degrees angle resulted in the highest percentage kill (98%).This could be understood as follows; the number of cycles that the snails go through as a result of the swirling action will increase as the diameter of the swirl decreases for the same traveling distance of the snails (Fig 38). And the more cycles the snails undergo , the more they are destroyed and crushed. And also the velocity increases as the swirling diameter gets smaller and this is because of the continuity equation Q =V*A so if the area and hence the diameter decreases the velocity increases - by having each time the same discharge "Q"-. This is important to know because it is known that the snails are killed and can't withstand the high velocities. So the smaller diameter destroys and hence kills more snails.

3 The parallel configuration (two concentric swirlers within each other) of the swirler kills more snails (94%) than a single swirler that has a diameter equal to that of the inner swirler of the parallel setup. This could be explained as follows; the outer and inner swirlers will cause two paths of swirling motion or in other words two concentric vortices (Fig 38) which is stronger than the vortex that will be generated if the inner swirler was working alone. So the parallel setup will destroy and hence kill more snails .

4 The heat (50° c) has a minimal effect (93%) on the increase in the percentage kill of the snails. To raise the temperature more than that will be very expensive because it consumes lots of energy. Raising the temperature will also require a specially

designed apparatus for killing the snails because the high temperature could damage the material , the joints , the pumps ..etc. of the apparatus which will also cost lots of money. Also raising the temperature more than that will result in thermal pollution.

5- Decreasing the volume flow rate of water and thus the velocity of the flow- snails - results in low percentage kill of the snails. The percentage kill (70%) of the snails of the strain Bulinus is less than at the strain Biomphalaria (92%) at the same swirler size and angle.. This means that the Bulinus snails have a more resisting shell. This is because their shell is more of the flat shape than the shell of the Biomphalaria snails so it is harder to crush them than to crush the other strain-Biomp.- of the snails.

6- Using a parallel setup with the smallest swirler size will be the most efficient way to have the highest percentage kill of the snails.

7- As for the fine screen mechanical cleaning system, it yielded the desired results and retained 100% of the snails. The mechanical cleaning system was designed to have a continuous cleaning process without blocking or affecting the flow.

5.2-Implementations

The proposed controlling apparatus will be placed at the intersection of two intersected canals one is a main canal and the other is a new constructed canal (branch) of a new community. This will lead to the result that no snails will be conveyed to the sub- canal so there will be a new community without schistosoma snails. The apparatus could

also be used in old communities where the irrigation is of the canal rotation system. Canal rotation is an irrigation system that let a field be irrigated from a particular canal then after irrigating the desired area the water is prevented from entering the canal by shutting the weir of the canal. Then another field with a second canal is irrigated and again after irrigation the water is prevented from entering the second canal and so on. Each canal will be left for about two weeks without water and this is because the crops need to be irrigated every two weeks. During the two weeks period the canals will dry out which in turn causes the snails in that canal to die since the snails cannot live without water. This will yield a clean canal. At that time the apparatus could be inserted at the canal's intersection with the river or with a larger irrigation canal.

The proposed implementation of the apparatus in real life is explained in the following paragraph. At the intersection of two canals a coarse screen will be constructed that is connected to a grit removal system similar to that of the waste water treatment plants (Fig. 39). This will retain the large floating debris. After the coarse screen a medium screen will be installed to further retain the floating debris that are relatively small in size. Then the canal is divided into several channels depending on the canals geometry and at each channel a swirl generator will be installed (swirlers will be made of plastic or if made of other materials it could be coated with an anti-oxidant). At the downstream side of the swirl generators the fine screen continuous cleaning system is installed in order to retain any fine debris or baby snails. After the cleaning system the pumping station could be constructed. Figure 40 represents a conceptual design of the apparatus in the field.

This set-up will ensure controlling the existence of snails in the short run. But with continuous usage it could nearly prevent the existence of the snails on the long run.

The following paragraph will discuss the effect of the system (swirling and screen continuous cleaning apparatus) on the environment and the aquatic life:

1- Biological impacts: A) The system will not harm the life balance of the aquatic system because the snails will be controlled and not totally prevented. B) The swirling motion will result in an aeration like process to the water in the canal so this could affect the aquatic life but in a minor way.
2- Chemical impacts: There will be no chemical pollution to the environment and the aquatic life because no chemicals are used.
3- Physical impacts: Maybe the velocity and the water level in the sub-canals will be changed slightly from their initial status because of the insertion of the hydraulic structures (screens and swirlers) in them. So care and attention should be paid when implementing the system in the field (it should be constructed in a way as to minimize the change in velocity and level of water).
- People's health: The system will improve on the people's health because it will control and lessen the infection rates with Schistosomiasis. So people will be more productive and this in turn flourishes the economy.

5.2.1 Recommendation for future work

Based on the experimental investigations, a need to optimize the geometry; as well as, the number of blades should be further investigated. Also if swirling angles less than 15 degrees could be constructed then it should also be investigated. Also it is further recommended to change the number of snails used in the experiments, because this can affect the percentage kill of the snails as follows : If the number of snails increases then the impact of snails with each other will also increase and thus the percentage kill will increase.

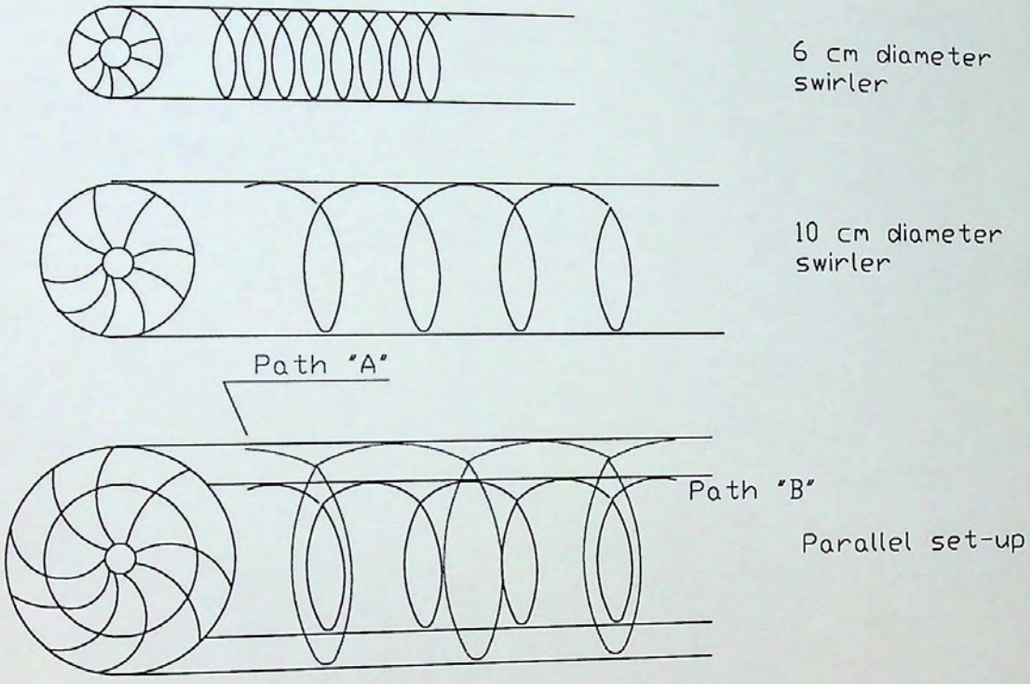


Fig. 38 : Swirling flow patterns

Fig. 39 : A) General view of the coarse manual screen

Fig. 39 : B) Coarse manual screen

Fig. 39 : C) Channel where the debris that are retained from the coarse manual screen are collected.

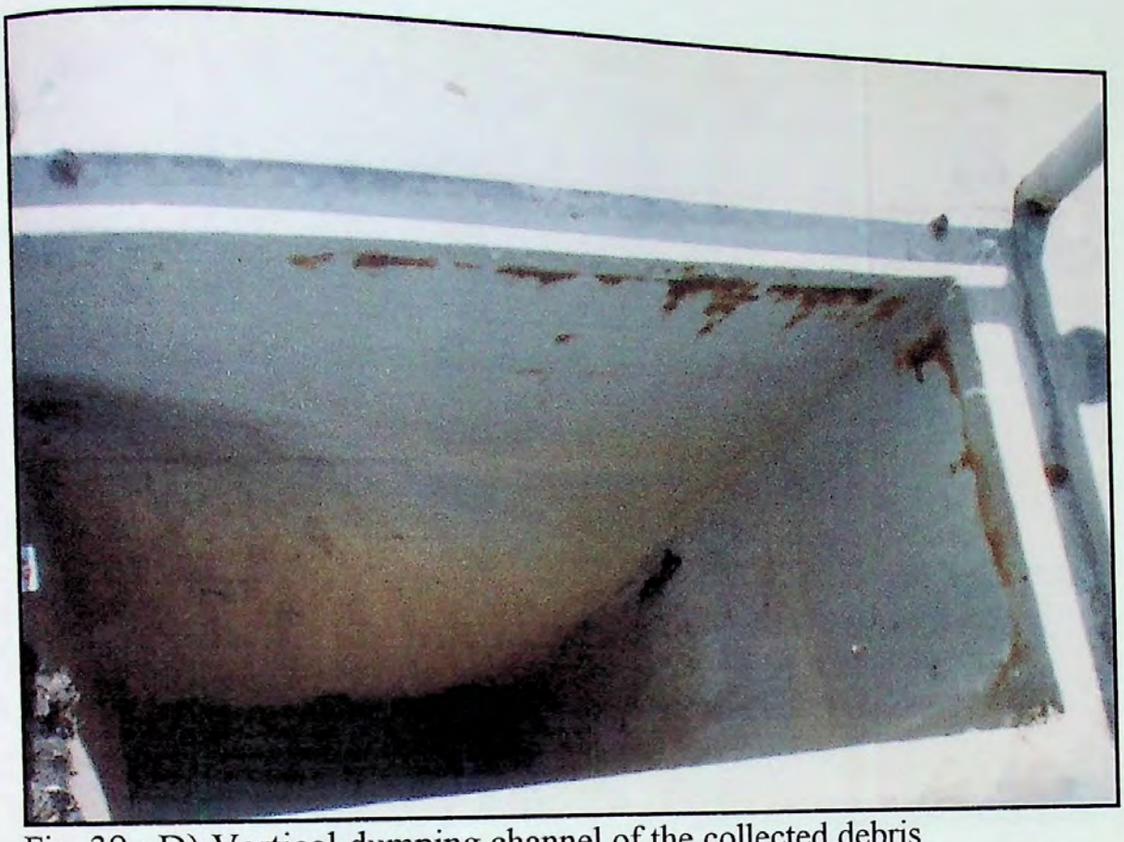


Fig. 39 : D) Vertical dumping channel of the collected debris

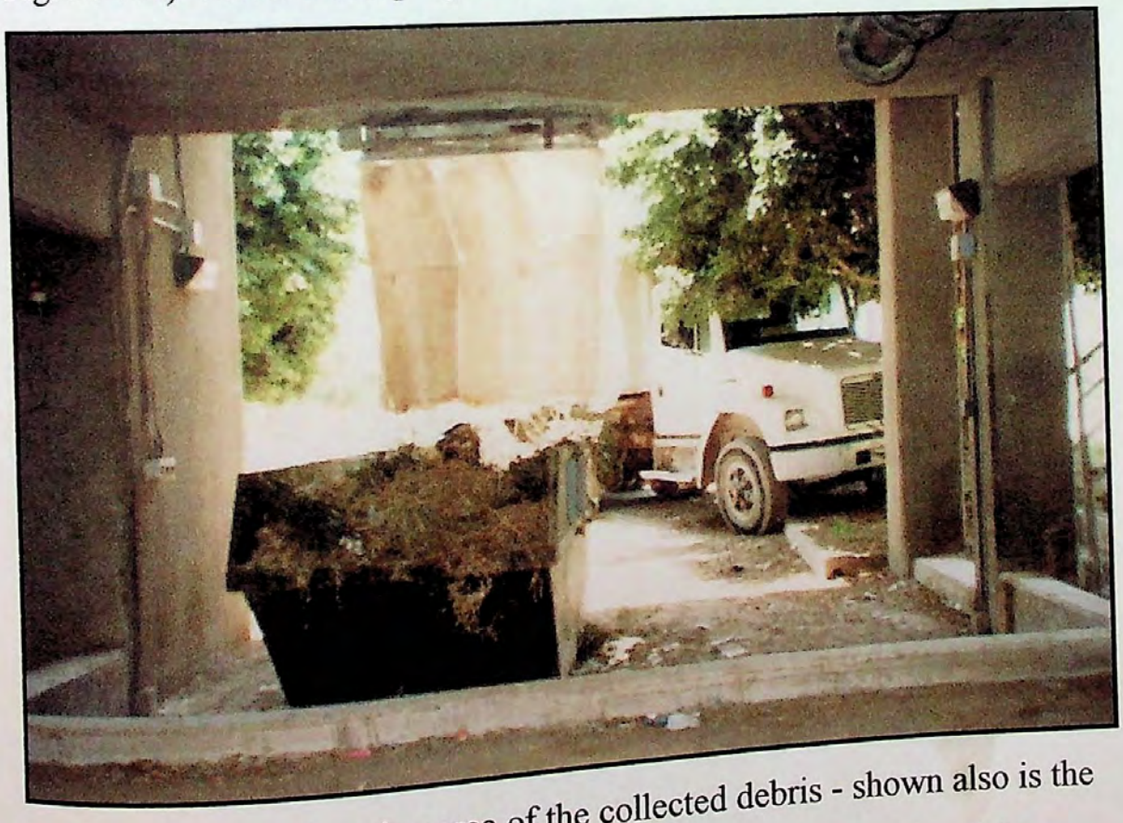


Fig. 39 : E) Final dumping area of the collected debris - shown also is the connection between the vertical dumping channel and the final dumping area)

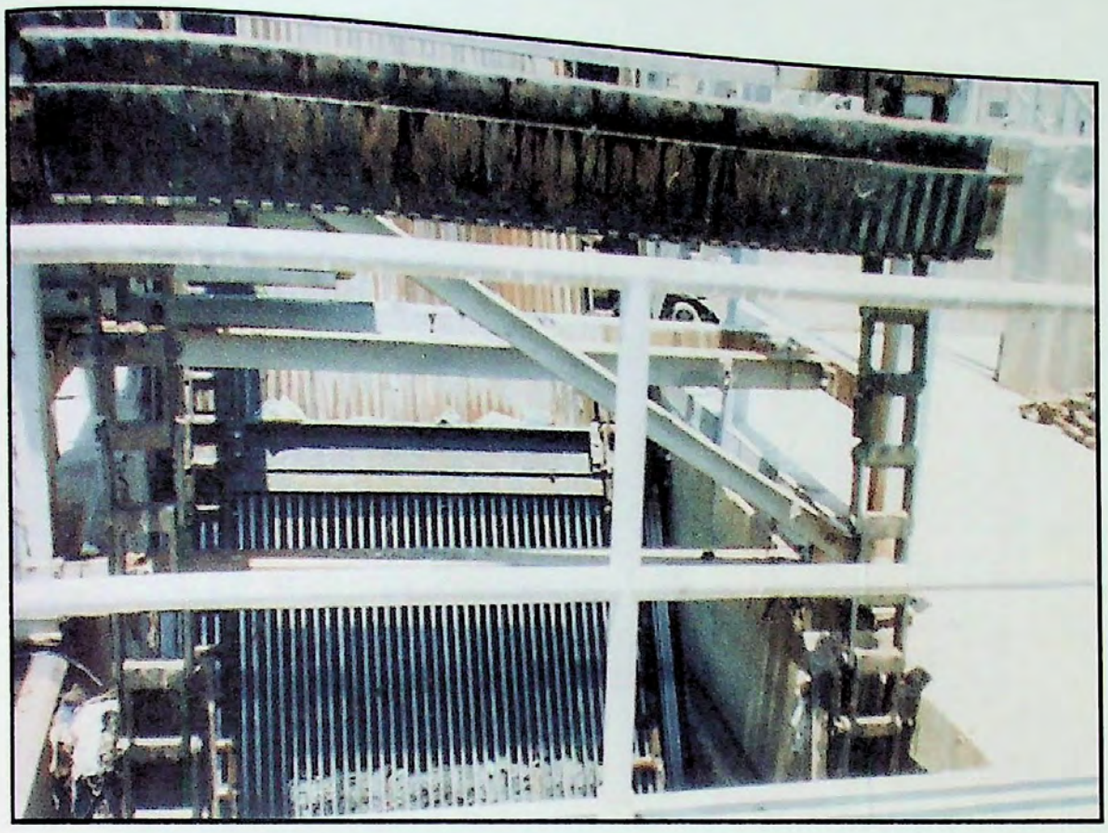


Fig. 39 : F) Mechanical coarse screen front

Fig. 39 : G) Mechanical coarse screen side

Fig. 39 : H) Mechanical coarse screen side back

Fig. 39 : I) General view of the grit removal

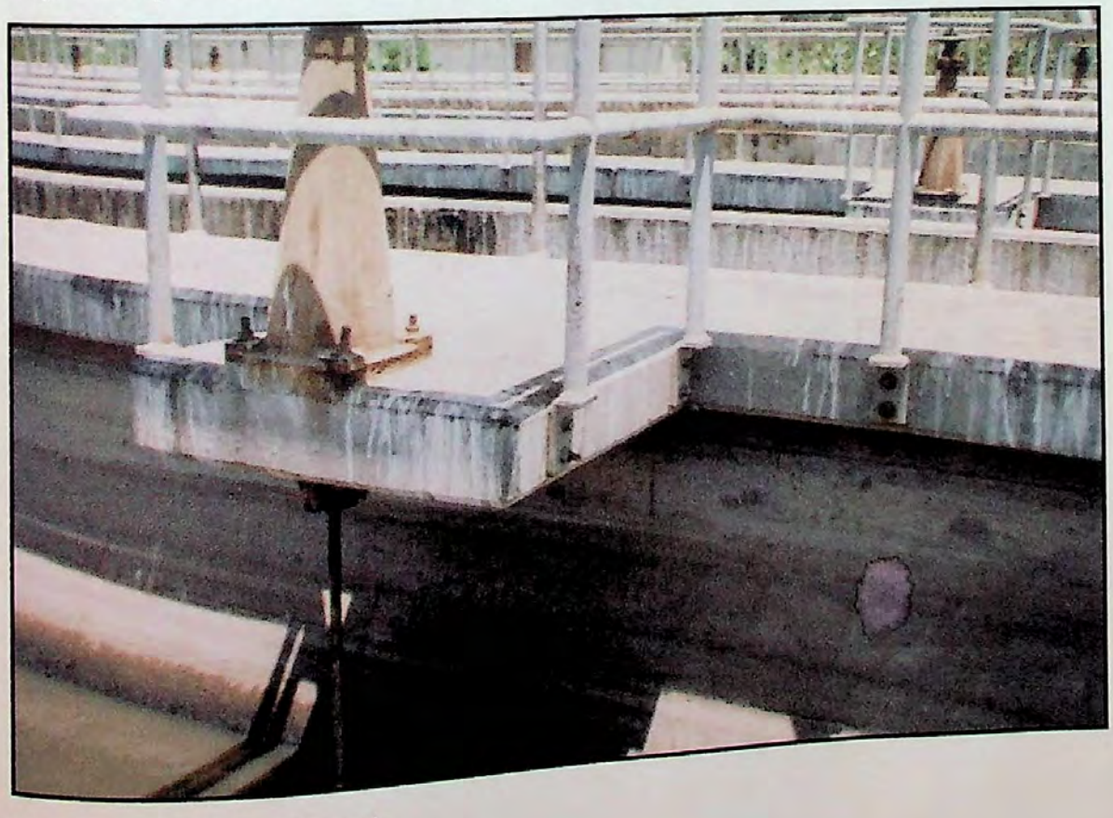


Fig. 39 : J) Grit removal

Fig. 39 : K) Dumping area of the grit removal system

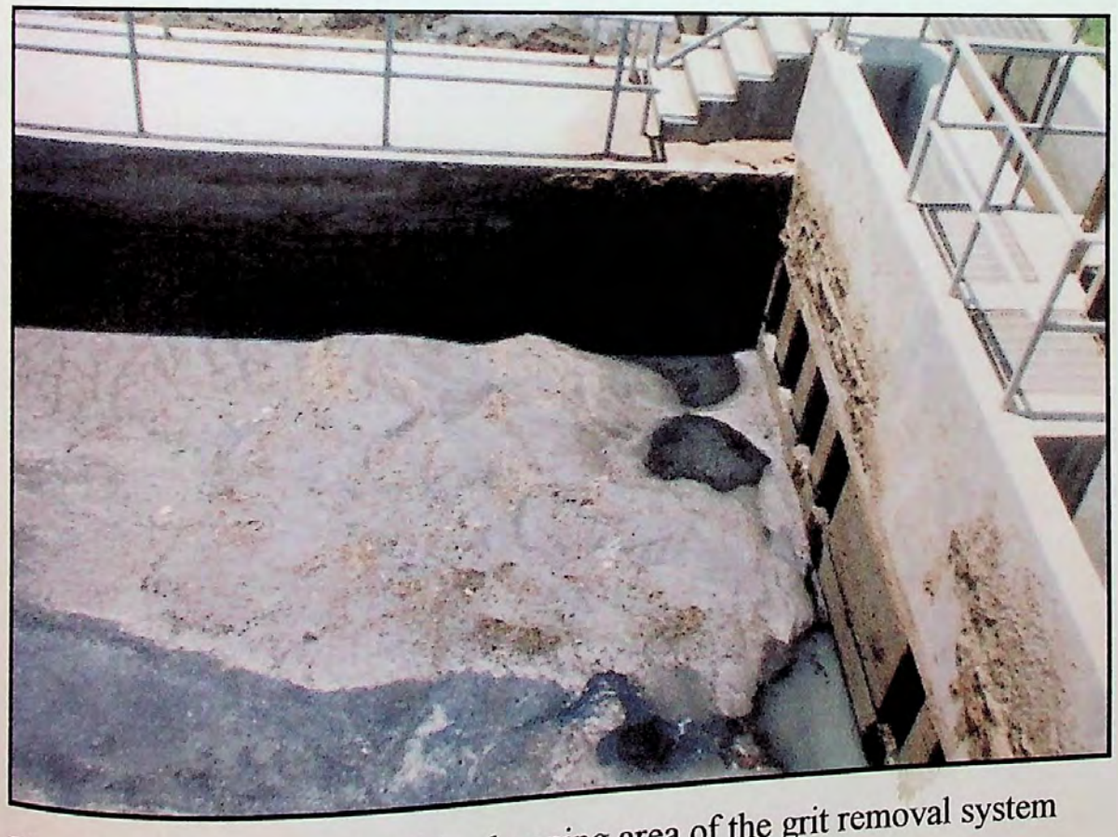


Fig. 39 : L) Closer view of the dumping area of the grit removal system

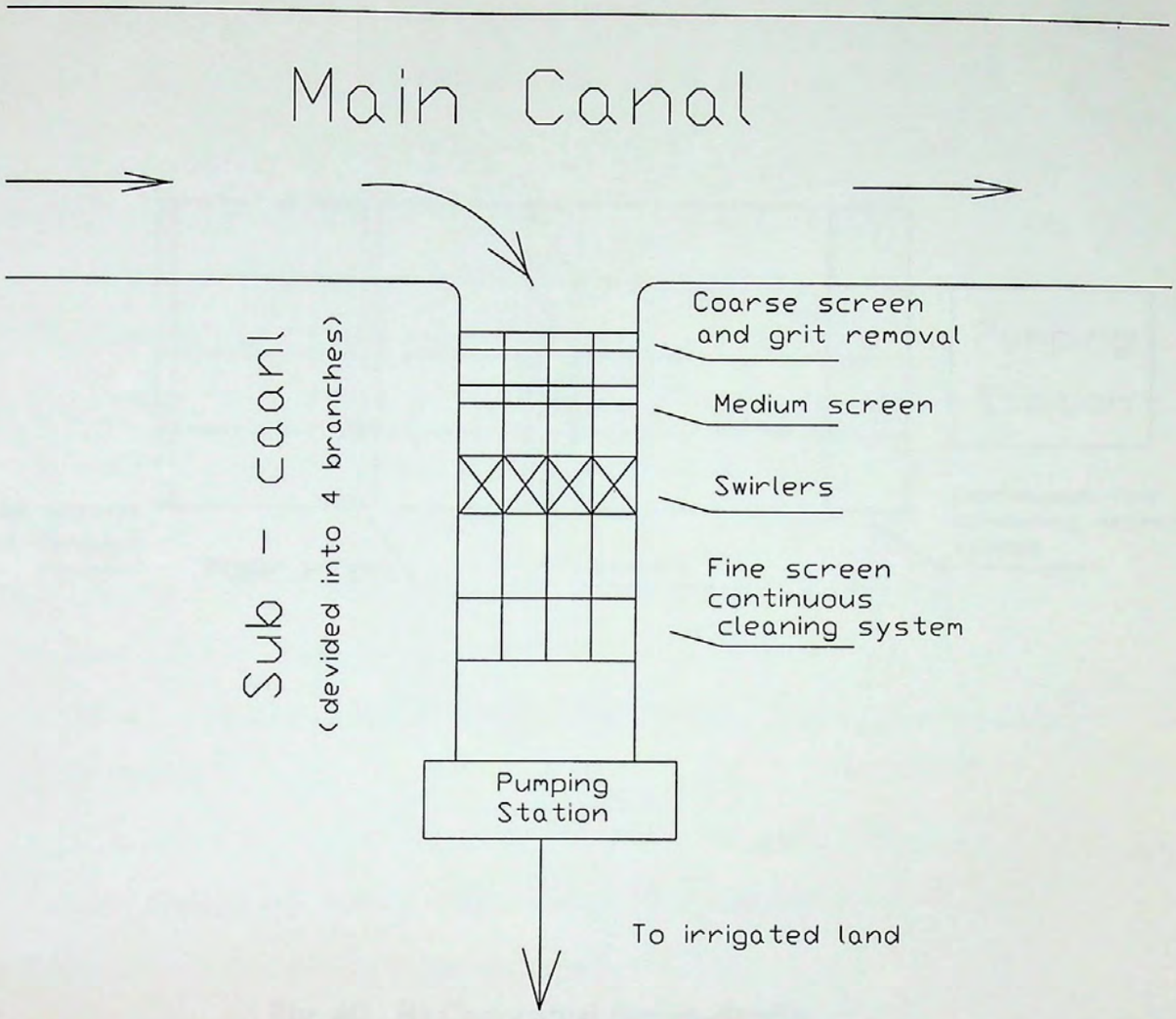


Fig. 40 : A) Conceptual design-plan view-

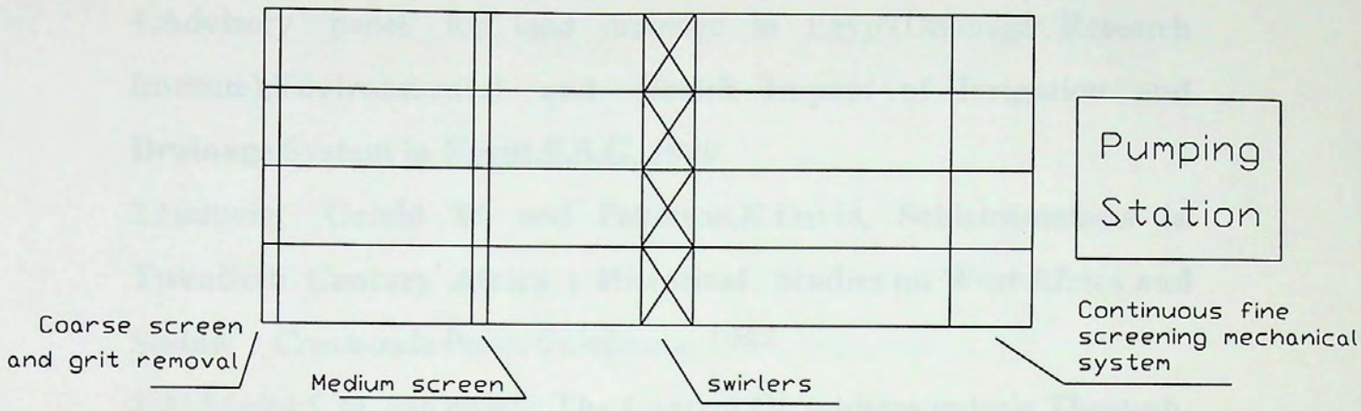


Fig. 40 : B) Conceptual design-details-

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