# Editorial

## The first ornithological study in Majuli

*In eleven-twelve century there was a small state namely 'Habung' in the present districts of Lakhimpur, Dhemaji and Majuli. Here the inhabitants mostly were the Mising, Kalitas and Chutias and the area was ruled by the Bhuyans. This state was tearned with Bio-diversity. Later on Ahom king Chu-Ka-Pha occupied the state and one of his successors, Swargadew Gadadhar Singha, who was a nature lover and mighty administrator engaged 'Charai Choa Barua' - the observer and conservator of Birds. He declared the migratory birds dominated area of Ratanpur-Gayangaon of Majuli as 'Chorai Chung' (habitat of Birds) and it was conserved specially. May be, this is the first royal or Govt. declared Bird Sanctuary in the world. But, such heritage area for birds was un-researched till the year of 2003. We, the Aranya Suraksha Samiti - Assam requested to the vice-Chancellor of Assam Agriculture University Dr. K. M. Bujarbaruah to make a study on the Birds of Majuli, specially in Dakshinpat wetland, known as 'Rambalia' which is a pocket of migratory as well as local birds of Majuli. Dr. Bujarbaruah sir immediately responded and directed Dr. Prabal Saikia, a reknowned ornithologist of Assam Agri. University, to make the research and compiled the checklist of the birds of Dakshinpat wetland. Accordingly Dr. Prabal Saikia took the responsibility and researched the birds and compiled the list of birds scientifically. This issue of 'Green Letter' is a special issue, where only the report of this study has been published. We feel it as an historical work which may help to declare Dakshinpat wetland as 'Bird Sanctuary' and also support the demand to declare Majuli as world heritage site, which is a long term demand of the people of Assam. We also hope that the Govt. of Assam will take necessary steps to declare Dakshinpat wetland as a Bird Sanctuary and support the venture.*

***Acknowledgement :***

***(A) Dakshinpat Satra, Majuli:*** *the 'Rambalia' Beel is a property of Dakshinpat Satra. But, Satradhiker Mr. Nani Gopal Dev Goswami is very much enthusiastic to conserve the wetland as a bird sanctuary. He suggested us to take necessary steps in this regard in the year 2003 itself, when Mr. Nirmal Kr. Bora was the president of Majuli District Aranya Suraksha Samiti. Accordingly we started our venture and the study report is the output of this. We do offer our respectful thanks to Satradhiker Goswami for his kind support, co-operation and suggestion in this regard.*



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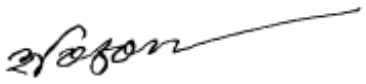
***(B) Dr. K. M. Bujarbaruah**, Vice Chancellor of Assam Agri University and **Dr. Prabal Saikia**, the ornithologist of AAU deserve our gratitude for their kind effort on the research, without which it would not been possible to complete the work.*

***(C) Mr. Janardan Goswami**, the president of Majuli District Aranya Suraksha Samiti organized the work with Dr. Prabal Saikia. We also offer our heartfelt thanks to him.*



(Dr. Haricharan Das)



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# Induced Breeding of *Clarias batrachus* (*Magur*) without stripping and sacrificing the male brooders

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## Abstract

*Induced breeding of **Clarias batrachus** (Magur) is possible without stripping and sacrificing male which is completely against the Prevailing practice i.e. impossible without sacrificing the male. In this study it is established that magur seed can be produced through hormone injections without stripping and sacrificing male brooders. From the experiment, it is found that the most effective dose is 0.25 ml per 100 gm body weight for both male and female in Assam. It is also found that if brooders are used repeatedly for 2nd time in the next year, breeding performance such as fecundity, hatching, survivality and growth of seed is not significantly affected. Same result can be obtained if the seed produced by stripping-less method (F1) are raised as brood fishes for breeding in the succeeding years.*

## Key word

***Clarias batrachus*,** magur**,** induced breeding, ovatide, stripping, sacrifice, repeated breeders, first generation.

## Introduction

The Asian catfish, Magur (*Clarias batrachus*) is well known for high protein and low fat content that can be cultured alone (monoculture) or along with carps (poly culture) system which can tolerate very low $DO_2$ level. This fish is highly nutritious containing 32.0 g protein, 2.0 g fat, 0.7 g iron, 172 mg calcium, 300 mg phosphorus and 66.3 g moisture in every 100 g flesh. In India, particularly in Assam there are abundant derelict and swampy waters which may be used for magur culture. The major drawback in adoption of magur culture, including other air-breathing fishes is non-availability of seed.

*Clarias batrachus* is one of the most popular food fish of India, Myanmar, Bangladesh, Sri lanka, Malaysia and many other Asian countries. It attains maturity within the second year of life and spawns in both open and confined waters in Assam. It breeds in



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shallow marginal waters of ponds, ditches and natural depressions, and inundated paddy-fields during summer monsoon and rainy season, usually between May and August (1, 2). Induced breeding techniques for *C. batrachus* have been successfully used for seed production by several researchers using natural and synthetic agents like fish pituitary gland extracts, Human Chorionic Gonadotropin (HCG), Ovaprim, Ovatide etc. [3,4,5,6]. But, in all the earlier successful artificial propagation of *C. batrachus* it involves stripping of eggs from the female and fertilizing with homogenate of mature testes in 0.9% sodium chloride (NaCl) solution. As the males are sacrificed in this method which is considered as a brutal act, there is a need for developing induced breeding technique without sacrificing the male. There is also a need for suitable nursing technique with practical success, especially till the seed reaches air breathing stage. Therefore, the present study was made for optimizing the breeding technique without striping and without sacrificing the male. The species had been bred by the author in confined water without stripping. It was observed that production of seed of *Clarias batrachus* without stripping is easier than the other previous methods involving stripping. Added advantage is that there is no need for sacrificing the brooders and repeated use of same brooders in the next year.

**Materials and Methods:**

The experiment was conducted at Fish Seed Farm, Regional Fisheries Training Institute, Amranga located 30 km away from Guwahati city of Assam. The experiment was conducted in 2013 for the first time with little success. In the next year (2014) the experiment was conducted again with encouraging results. During 2015 and 2016, it has been repeated for standardization of doses and technique which also yields better results and contributes towards attaining self confidence on this innovation. In 2016 even the seed produced by this method during 2014 is used as brooders for successful seed production.

**Brood stock management:**

Successful seed production of *Clarias batrachus* largely depends upon the maintenance of healthy brood fish. Magurs collected from different sources were cultured at earthen ponds in the farm for last 1-2 years to raise them to brooders.In the month of February, collected brooders from the farm ponds were stocked in a specially prepared earthen pond (20 m x 5 m x 1.2 m) at 1-2 broods per square meter and fed regularly with a mixture of fishmeal (60%), ground nut oil cake (25 %), rice polish (13%) and vitamin & mineral mixtures (2%) @ 2% – 3% of body weight/ day until they attain maturity during Feb-June.



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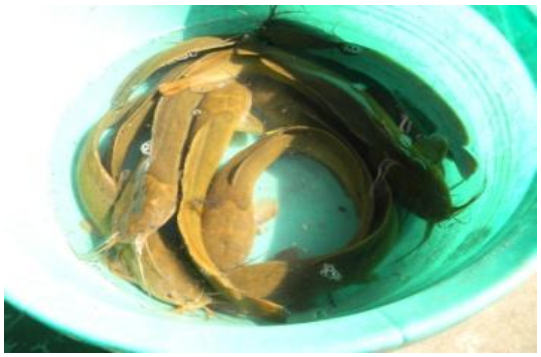

Plate1: Brood fish of Magur *Clarias batrachus*

**Captive spawning:** Healthy, matured brooders were selected for induced breeding. *Clarias batrachus* usually breed during May to August in Assam. Males and females were distinguished on the basis of external morphological features [7,8]. The abdomen of gravid female is bulging with reddish coloured vent having round shaped genital papilla, where as the males have elongated and pointed papilla. One female and two males were selected for breeding for each trial.

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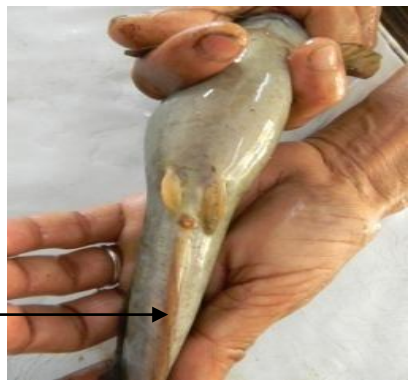
Genital papilla of female



Genital papilla of male

Plate2 : Genital papilla of male and female brood fish of *Clarias batrachus*

Induced breeding was performed administrating ovatide as a single dose for both male and female @ 0.25 ml per 100 gm and each trial in different years as shown in Table 1 - 4. After injection both male and females were released in the breeding tank (cemented) of 1m x 1mx1m size where water depth was maintained at 0.3 m.



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Plat3: Showing intramuscular injection to the brood fish of Magur for induced breeding.

Eggs and milt were released within 24 hrs and fertilized. Both male and female were taken out immediately after fertilization from the breeding tank. Vigorous aeration was provided in the breeding tank as a precaution to avoid rapture of eggs. The fertilized eggs are adhesive in nature and orange in colour initially which eventually turns in to the light brown colour after 6-8 hours.Water temperature in spawning tank was between 26˚ C – 31˚ C and hatching was completed within 26 hours. The yolk sac of newly hatched larvae got absorbed within 72 -96 hrs. The hatchlings were transferred to a cemented tank of similar size for rearing.

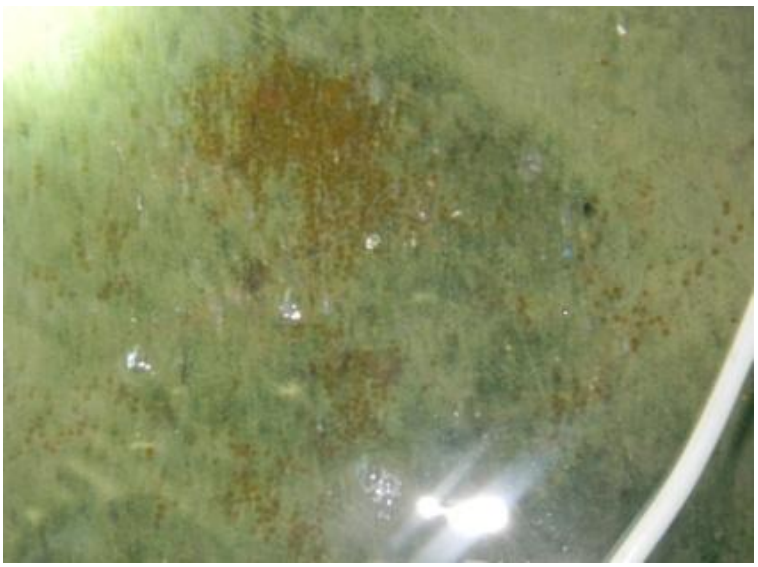

Plate4: Fertilized eggs of Magur *Clarias batrachus* at cement tank..

**Production of fry:** Larval rearing was done at a cemented tank of 1 m x 1 m x 1 m size. As *Clarias batrachus* larvae are very delicate, special care was taken for their better growth and survival during rearing in cemented tank. Vigorous aeration was provided in the larvae



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rearing tank. Due to heavy weight of yolk sac they do not move during the early stage. It was observed that they show tail lashing till yolk sac is absorbed which required almost 72 – 96 hrs. At that time larvae moves in shoal to the side or corner of the tank. After yolk sac absorption the barbells, jaws, operculum and gills become prominent. Larva was stocked at 2500 – 3000 nos. per $m^2$ water area. Average growth of larvae obtained 25 – 30 mm within 30 days of rearing. Survival rate was 60% – 70%.

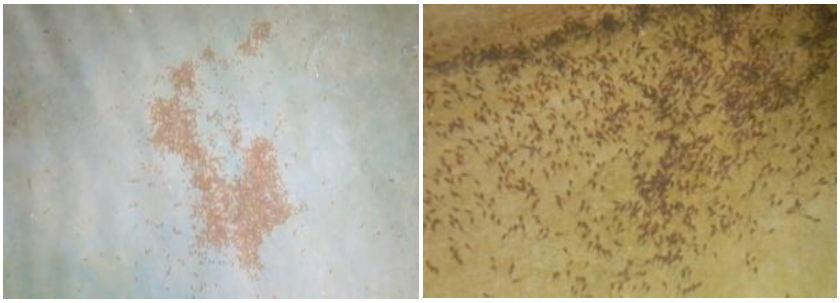

Plate5: Newly hatch larvae of Magur *Clarias batrachus* at cement tank

Newly hatched larvae started taking food after absorption of the yolk sac. For the first four days, larva were fed with Artemia nauplii 3 – 4 times in a day and then with live zoo planktons for next one week. Live planktons is considered well accepted feed for rearing *Clarias batrachus* larvae as the plankton remain in live condition in the rearing tanks. The larvae can feed on them as and when required. The supply of live plankton was withdrawn gradually with the introduction of artificial feed till they obtain 25 – 30 mm in length. Artificial feed was prepared with wheat flour (30%),milk powder (6%), fish meal (35%), egg yolk (25%), vitamin and mineral mixture (4%).

Plate6:Fry of Magur *Clarias batrachus* at cement tank

Quality and water depth of the rearing tank play an important role for growth and survival of *Clarias batrachus* larvae. Water depth of the larvae tank was maintained at 0.3m. Vigorous



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aeration was provided with a blower. Unconsumed feed and accumulated metabolites were removed twice a day by siphoning and water exchange was done at 10% level.

**Production of fingerlings:**

Small size cemented tanks of 2.5 m x 1 m x 1 m area with 3 cm – 4 cm soil base were used for fingerling production. Water level maintained at 0.3 m. Raw cow dung was applied @ 3 kg per tank and inoculated with plankton. After 10 days tanks were stocked with fry of 25 – 30 mm size @ 250 nos per $m^2$. Floating weeds (water hyacinth) were provided for shade and shelter. Each tank was covered with nets to prevent external predators. Atleast 10 % water exchange was done regularly.

Plate7: Fingerings of Magur *Clarias batrachus* at cement tank.

In addition to plankton, artificial feed was provided at 4 – 5% body weight 3 times a day. The feed quantity was increased or decreased by observing quantity of left out feed in the tank. Fry are reared for 40 days in rearing tank.

**Harvesting:** Usually fry grow up to 1 gm in weight during 30 – 40 days of rearing when fingerlings can be harvested. It has been seen that another 2 – 3 months rearing period is required for growing them to 6 – 7 gm in weight that are suitable to stock in the growing pond. Proper size segregation of fingerlings is required to reduce the competition for food and cannibalism.



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**Result and discussion:**

The spawning performances of ***Clarias batrachus*** at different doses of ovatide are present in Table 1 – 4.

Table 1

Trial of first Year : 2013

| Sl no | Trial | Weight (gm) | | | Dose of ovatide (ml) | Eggs obtained (nos) | Hatching %age | Survival % age in Larval rearing (Nursery tank) | Survival % age in Fry rearing (Rearing tank) |
|---|---|---|---|---|---|---|---|---|---|
| | | Female | Male 1 | Male2 | | | | | |
| 1 | 1 | 150 | 120 | 125 | 0.10 | - | - | - | - |
| 2 | 2 | 130 | 130 | 110 | 0.15 | - | - | - | - |
| 3 | 3 | 160 | 110 | 130 | 0.25 | 657 | Nil | - | - |

Table 2:

Trial of Second Year : 2014

| Sl no | Trial | Weight (gm) | | | Dose of ovatide (ml) | Eggs obtained (nos) | Hatching %age | Survival % age in Larval rearing (Nursery tank) | Survival % age in Fry rearing (Rearing tank) |
|---|---|---|---|---|---|---|---|---|---|
| | | Female | Male 1 | Male2 | | | | | |
| 1 | 1 | 140 | 110 | 120 | 0.20 | 2600 | 43 | 56 | 42 |
| 2 | 2 | 150 | 120 | 125 | 0.25 | 3400 | 60 | 62 | 45 |
| 3 | 3 | 160 | 125 | 130 | 0.30 | 3100 | 44 | 58 | 47 |



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Table 3:

Trial of Third Year : 2015

| Sl no | Trial | Weight (gm) | | | Dose of ovatide (ml) | Eggs obtained (nos) | Hatching %age | Survival % age in Larval rearing (Nursery tank) | Survival % age in Fry rearing (Rearing tank) |
|---|---|---|---|---|---|---|---|---|---|
| | | Female | Male 1 | Male2 | | | | | |
| 1 | 1 | 150 | 130 | 130 | 0.25 | 4200 | 64 | 70 | 43 |
| 2 | 2 | 160 | 130 | 125 | 0.25 | 4300 | 70 | 69 | 48 |
| 3 | 3 | 210 | 200 | 190 | 0.25 | 5300 | 71 | 70 | 45 |

Table 4:

Trial of Fourth Year : 2016

| Sl no | Trial | Weight (gm) | | | Dose of ovatide (ml) | Eggs obtained (nos) | Hatching %age | Survival % age in Larval rearing (Nursery tank) | Survival % age in Fry rearing (Rearing tank) |
|---|---|---|---|---|---|---|---|---|---|
| | | Female | Male 1 | Male2 | | | | | |
| 1 | 1 | 150 | 130 | 125 | 0.25 | 3900 | 74 | 63 | 42 |
| 2 | 2 | 150 | 140 | 135 | 0.25 | 4100 | 78 | 68 | 48 |
| 3 | 3 | 220 | 210 | 200 | 0.25 | 4600 | 73 | 63 | 44 |

A total of three trials i.e. $13T_1$, $13T_2$, $13T_3$ were conducted using stripping less technique during 2013. Ovatide were injected @0.10,0.15, 0.2 per 100 gm body weight respectively in $13T_1$, $13T_2$ and $13T_3$ . In $13T_1$ and $13T_2$ female did not respond i.e. no eggs were released, but in $13T_3$ only 657 no. of eggs were released but not hatched. Artificial aeration was not done in all the trials.



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During 2014, again three trials i.e. $14T_1$, $14T_2$, $14T_3$ were conducted using different dose of Ovatide @ 0.20 ml , 0.25 ml a& 0.30 ml per 100 gm of body weight of fish respectively in $14T_2$ maximum nos. of eggs obtained followed by $14T_3$ then $14T_1$. Similarly percentage of hatching in $14T_2$ was found maximum.

Same procedure was followed during 2015 also where $15T_1$, $15T_2$ & $15T_3$ were conducted using 0.25 ml and ovatide per 100 gm body weight of fish. The brooders used in $15T_1$ were collected from local farmers tank, $15T_2$ were collected from farm tank but used in breeding for the first time and 15 $T_3$ brooders were from the farm tank itself but they were used for the second time means they were used as brooder in 2014 also. In all this trials, i.e. $15T_1$, $15T_2$, $15T_3$ nos. of eggs obtained per body weight and percentage of hatching and survivality are almost same. Although in $15T_1$ is slightly lower.

Following same technique $16T_1$, $16T_2$ and $16T_3$ were conducted during 2016 where in $16T_1$ , fresh brooders from farm tank , $16T_2$ repeated brooders and $16T_3$ brooders were from the first generation obtained from stripping less breeding were used in all these three trials, no. of eggs obtained, % of hatching, survivality , good performance are found to be almost similar.

**Conclusion**:

From all these trials , it may be conclude that seed of *Clarias batrachus* can be produced by injecting synthetic hormone i.e. ovatide effectively @ 0.25 per 100 gm body weight without stripping and sacrificing male. Further it may be conclude that brooders can be repeatedly used in the next year without any adverse quality of produced seed. Another finding is that breeding performance of seed produced by stripping-less technique is same as that of normal brooders if they were used as brooders.



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# Formula of calculating accurate volume of pond with slanting side (slope)

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***Abstract**:*

*Calculation of accurate volume of a pond is very important for various purposes such as cost of excavation, for calculation of amount of chemical or medicine to be applied, calculation of amount of water etc. Generally two types of simple methods are being used but both are given different values, both of which are not correct means both differ from accurate value of volume. This difference between results obtained by these two methods and accurate volume increases along with increase in depth and side slant (slope). Another method may be used which gives accurate volume but it is very complicated where formula of volume for triangle, pyramid and cuboid are required to be used, that is why probably this method is not popular or not being used by people. Here a simple formula is developed denoted as AD's (Abani-Debabrat's) pond volume formula which gives the accurate volume of a pond with slanting side (slope) and very easy to remember due to its simplicity. If we know the pond area means Pond Top Length and Pond Top Width and side slant (slope) and Pond Depth; then we can calculate out Pond Bottom Length and Pond Bottom Width. By knowing Top Length and Width, Bottom Length and Width and Pond depth we can easily calculate out accurate volume of a pond as given below:*

$$\text{Volume} = \text{Average area} \times \text{Depth}$$

$$= \frac{(\text{Top area} + \text{Bottom area} + \text{Swap area})}{3} \times \text{Depth}$$

***Swap Area** is the average of **"Cross Variable Factor Multiplication Area (CVFMA)"** both of which are complete newly incorporated concept. We calculate area of any rectangular/square surface by multiplying Length with Width of that particular surface and both these factors, (i.e. Length and Width) vary with the size of the surface. The CVFMA is calculated for two inter related surface where one variable factor (Length or Width) of one surface is multiplied with the other variable factor (Width or Length) of other surface, that is*



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*why for two inter-related surface (say top and bottom surface of a pond) we will get two CVFMA. Say, CVFMA.1= Top Length x Bottom Width and CVFMA.2 = Bottom Length x Top Width and Average of these two CVFMA (1 and 2) is denoted here as Swap Area. It means, by formula*

$$\text{Swap Area} = \frac{\text{CVFMA.1 + CVFMA.2}}{2}$$

$$= \frac{\text{(Top Length x Bottom Width) + (Bottom Length x Top Width)}}{2}$$

**Key word:** Existing formula of volume, Standard formula of area as well as volume for triangle, pyramid and cuboid, Cross variable factor multiplication area, Swap area.

## Introduction :

Generally a pond with slanting side is a very unique structure. Calculation of accurate volume of a pond is very important for various purposes such as cost of excavation, for calculation of amount of chemical or medicine to be applied, calculation of amount of water etc. From the very old days to till now generally two types of method are being used to calculate volume of a pond as below:

A) Pond Volume = Average Length x Average Width x Depth

$$\text{or } \frac{\text{Top Length + Bottom Length}}{2} \times \frac{\text{Top Width + Bottom Width}}{2} \times \text{Depth}$$

B) Pond Volume = Average Top-Bottom area x Depth

$$\text{or } \frac{\text{Top area + Bottom area}}{2} \times \text{Depth}$$

Although both of these two methods of calculating volume is simple but both of them are given different values, means one or both of which are not correct or not given accurate value of pond volume. The deviation of the results obtained by these two methods from accurate volume increases along with increase in depth and side slant (slope).



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C) Another method may be used which gives accurate volume but it is very complicated where formula of volume for triangle, pyramid and cuboid are required to be used. For this 3rd method we have to dissect the pond into some parts which will give one cuboid, two equal parts of triangular structure Length-ward, two equal parts of triangular structure Width-ward and four equal parts of rectangular based pyramid structure. So,

Pond volume= Volume of Cuboid + 2 x Volume of Length-ward triangle + 2 x Volume of Width-ward triangle + 4 x Volume of rectangular based pyramid.

Probably this method is not popular or not being used by people due to its complicacy although it gives the accurate volume of a pond.

D) In this research work we have tried to find out any simple concept and formula that gives the accurate volume of a pond. We have developed a very new concept and based on that concept we frame out a new Formula for calculation of accurate pond volume and denoted that formula as AD's volume formula and tried to check out the accuracy of the formula. Before going to use this formula we should know the newly introduced concept of ***"Swap area"*** and "***Cross variable multiplication area"*** for calculation of accurate volume of a pond. ***Swap Area*** is the average of ***"Cross Variable Factor Multiplication Area (CVFMA)"*** both of which are complete newly incorporated concept. We calculate area of any rectangular/square surface by multiplying Length with Width of that particular surface and both these factors, (i.e. Length and Width) vary with the size of the surface. The CVFMA is calculated for two inter related surface where one variable factor (Length or Width) of one surface is multiplied with the other variable factor (Width or Length) of other surface, that is why for two inter-related surface (say top and bottom surface of a pond) we will get two CVFMA. Say, CVFMA.1= Top Length x Bottom Width and CVFMA.2 = Bottom Length x Top Width and Average of these two CVFMA (1 and 2) is denoted here as Swap Area.

**Materials and Methods**:

We have calculated volume of a pond using all available methods as well as our newly developed method. Let start with a pond having Length of 100 unit, Width of 50 unit and Depth of 3 unit along with side slant (slope) 1: 1. (run: rise).

As the side slant (slope) is 1:1 which means for every unit of depth vertical measurement decreases 1 unit in one side, so in both side vertical measurement will decrease



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2 unit. Therefore, for 3 unit of depth all total 3x2=6 unit will decrease for both sides. Now all the measurements will be as below:

Top Length (TL) = 100 unit
Top Width (TW) = 50 unit
Bottom Length (BL) = 100 - 6 = 94 unit
Bottom Width (BW) = 50 - 6 = 44 unit
Depth (D) = 3 unit

A) According to average Length-Width method,

$$\text{Pond volume} = \text{Average Length} \times \text{Average Width} \times \text{Depth}$$
$$= \frac{TL + BL}{2} \times \frac{TW + BW}{2} \times D \text{ unit}^3$$
$$= \frac{100 + 94}{2} \times \frac{50 + 44}{2} \times 3 \text{ unit}^3$$
$$= 97 \times 47 \times 3 \text{ unit}^3$$
$$= 13{,}677 \text{ unit}^3$$

B) According to average area method,

$$\text{Pond volume} = \text{Average Top-Bottom area} \times \text{Depth unit}^3$$
$$= \frac{\text{Top area} + \text{Bottom area}}{2} \times \text{Depth unit}^3$$
$$= \frac{TL \times TW + BL \times BW}{2} \times D \text{ unit}^3$$
$$= \frac{(100 \times 50) + (94 \times 44)}{2} \times 3 \text{ unit}^3$$
$$= 13{,}704 \text{ unit}^3$$

1. One cube/Cuboid structure : Green colour part
2. Two equal triangular structure
   (Length-ward) : Blue colour part
3. Two equal triangular structure
   (Width-ward) : Pink colour part
4. Four rectangular based pyramid
   : Yellow colour part.

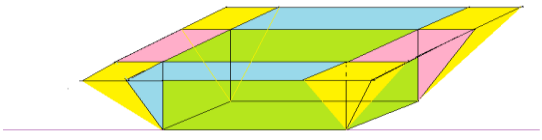

Fig.1: 3D – Pond View



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C) For dissecting method, we have to dissect the pond into several parts so that we can calculate volume of all parts conveniently. It is practically done in a pond like structured model (Fig.1) . For this purpose we have drawn four horizontal perpendicular lines from four bottom corners to the top of the pond which gives a cuboid/cube structure (Fig.2). Now we have extended all the top vertical line straight upto the side of the top surface of the pond which gives two equal Length-ward (Fig.3) and two equal Width-ward triangular structure (Fig.4) and four equal rectangular based pyramid (Fig.5) as shown in the figure(s) below:

After dissecting a pond following structure are found

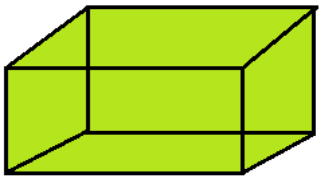

Fig.2: Cuboid part

Fig.3: Length-ward triangular structure

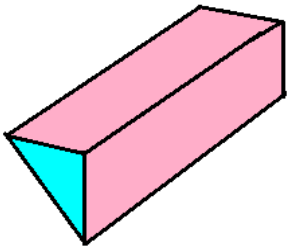

Fig.4: Width-ward triangular structure

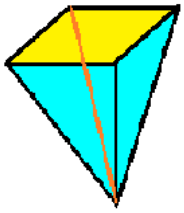

Fig.5: Rectangular based pyramid

So, the different measurements, area and volume of the above structures will be as below

**i. For cube/cuboid** Length (L) = 94 unit, Width (W) = 44 unit and Height (H) = 3 unit

So, Area of the cube/cuboid = L x W =94 x 44 = 4136 unit$^2$

And volume of the cube/cuboid = LxWxH= 94 x 44 x 3 = 12,408 unit$^3$

**ii) For Length-ward triangular structure,**

Base (b) =3 unit, Hypotenuse (h) = 3 unit and Length (L)= 94 unit

So, Area of the structure = 1/2 x b x h = 4.5 unit$^2$

And Volume of the structure = 1/2 x b x h x L= 423 unit$^3$

**iii) For Width-ward triangular structure,**

Base (b) =3 unit, Hypotenuse (h) = 3 unit and Length (L)= 44 unit

So, Area of the structure = 1/2 x b x h = 4.5 unit$^2$

And Volume of the structure = 1/2 x b x h x L= 198 unit$^3$

**iv) For rectangular (or square) based pyramid,**



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Length (L) = 3 unit, Width (W) = 3 unit and Height (H) = 3 unit
So, Area of the structure = 1/3 x L x W= 3 $unit^2$
And Volume of the structure = 1/3 x L x W x H= 9 $unit^3$

**Pond volume** = i) Volume of the cube + ii) 2 x Volume of Length-ward triangular structure + iii) 2 x Volume of Width-ward triangular structure + iv) 4 x rectangular (or square) based pyramid
= 12408 + (2 x 423) + (2 x 198) + (4 x 9)
= 12408 + 846 + 396 + 36
= 13686 $unit^3$

**D) According to AD's Volume method :**

Before going to use this formula we should know the newly introduced concept of swap area and Cross variable multiplication area for calculation of accurate volume of a pond. ***Swap Area*** is the average of ***"Cross Variable Factor Multiplication Area (CVFMA)"*** both of which are complete newly incorporated concept. We calculate area of any rectangular/square surface by multiplying Length with Width of that particular surface and both these factors, (i.e. Length and Width) vary with the size of the surface. The CVFMA is calculated for two inter related surface where one variable factor (Length or Width) of one surface is multiplied with the other variable factor (Width or Length) of other surface, that is why for two inter-related surface (say top and bottom surface of a pond) we will get two CVFMA. Say, CVFMA.1= Top Length x Bottom Width and CVFMA.2 = Bottom Length x Top Width and Average of these two CVFMA (1 and 2) is denoted here as Swap Area. It means,

$$\text{Swap Area} = \frac{\text{CVFMA.1} + \text{CVFMA.2}}{2}$$

$$= \frac{(\text{Top Length} \times \text{Bottom Width}) + (\text{Bottom Length} \times \text{Top Width})}{2}$$

The different measurement value of the pond for the above example will be as given below:

| | | | |
|---|---|---|---|
| Top Length (TL) | = 100 unit | Top Width (TW) | = 50 unit |
| Bottom Length (BL) | = 94 unit | Bottom Width (BW) | = 44 unit |
| Depth (D) | = 3 unit | | |

A] Top area = TL x TW = 100 x 50 = 5000 $unit^2$
B] Bottom area = BL x BW = 94 x 44 = 4136 $unit^2$
C] Swap area = $\frac{(TL \times BW) + (BL \times TW)}{2} = \frac{(100 \times 44) + (94 \times 50)}{2}$ = 4550 $unit^2$

**Volume of Pond** = Average area x Depth
= $\frac{(\text{Top area} + \text{Bottom area} + \text{Swap area})}{3}$ x Depth
= $\frac{(5000 + 4136 + 4550)\ unit^2}{3}$ x 3 unit
= 13686 $unit^3$



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## Table1 : Volume of pond Calculated by different method

| Top length (unit) | Top width (unit) | Depth (unit) | Side-slant/ Slope (run :rise) | Bottom length (unit) | Bottom width (unit) | Avg. Length & Width method $(unit)^3$ | Avg. Top - bottom area method $(unit)^3$ | Cuboid - triangle - pyramid method $(unit)^3$ | AD's pond volume method $(unit)^3$ |
|---|---|---|---|---|---|---|---|---|---|
| 100 | 50 | 1 | 1:1 | 98 | 48 | 4851 | 4852 | 4851.3333 | 4851.3333 |
| | | | 1:1.5 | 97 | 47 | 4777.25 | 4779.50 | 4778.00 | 4778.00 |
| | | | 1:2 | 96 | 46 | 4704.00 | 4708.00 | 4705.3333 | 4705.3333 |
| | | | 1:3 | 94 | 44 | 4559.00 | 4568.00 | 4562.00 | 4562.00 |
| | | | 1:5 | 90 | 40 | 4275.00 | 4300.00 | 4283.3333 | 4283.3333 |
| | | 2 | 1:1 | 96 | 46 | 9408.00 | 9416.00 | 9410.6667 | 9410.6667 |
| | | | 1:1.5 | 94 | 44 | 9118.00 | 9136.00 | 9124.00 | 9124.00 |
| | | | 1:2 | 92 | 42 | 8832.00 | 8864.00 | 8842.6667 | 8842.6667 |
| | | | 1:3 | 88 | 38 | 8272.00 | 8344.00 | 8296.00 | 8296.00 |
| | | | 1:5 | 80 | 30 | 7200.00 | 7400.00 | 7266.00 | 7266.66 |
| | | 5 | 1:1 | 90 | 40 | 21375.00 | 21500.00 | 21416.6667 | 21416.6667 |
| | | | 1:1.5 | 85 | 35 | 19656.25 | 19937.50 | 19750.00 | 19750.00 |
| | | | 1:2 | 80 | 30 | 18000.00 | 18500.00 | 18166.6667 | 18166.6667 |
| | | | 1:3 | 70 | 20 | 14875.00 | 16000.00 | 15250.00 | 15250.00 |
| | | | 1:5 | 50 | 0 | 9375.00 | 12500.00 | 12500.00 | 12500.00 |
| 200 | 170 | 1 | 1:1 | 198 | 168 | 33631.00 | 33632.00 | 33630.00 | 33630.00 |
| | | | 1:1.5 | 197 | 167 | 33447.25 | 33449.50 | 33448.00 | 33448.00 |
| | | | 1:2 | 196 | 166 | 33264.00 | 33268.00 | 33265.3333 | 33265.3333 |
| | | | 1:3 | 194 | 164 | 32899.00 | 32908.00 | 32902.00 | 32902.00 |
| | | | 1:5 | 190 | 160 | 32175.00 | 32200.00 | 32183.3333 | 32183.3333 |
| | | 5 | 1:1 | 190 | 160 | 160875.00 | 161000.0 | 160916.667 | 160916.667 |
| | | | 1:1.5 | 185 | 155 | 156406.25 | 156687.50 | 156500.00 | 156500.00 |
| | | | 1:2 | 180 | 150 | 152000.00 | 152500.00 | 152166.667 | 152166.667 |
| | | | 1:3 | 170 | 140 | 143375.00 | 144500.00 | 143750.00 | 143750.00 |
| | | | 1:5 | 150 | 120 | 126875.00 | 130000.00 | 127916.667 | 127916.667 |
| | | 9 | 1:1 | 182 | 152 | 276759.00 | 277488.00 | 277002.00 | 277002.00 |
| | | | 1:1.5 | 173 | 143 | 262685.25 | 264325.50 | 263232.00 | 263232.00 |
| | | | 1:2 | 164 | 134 | 248976.00 | 251892.00 | 249948.00 | 249948.00 |
| | | | 1:3 | 146 | 116 | 222651.00 | 229212.00 | 224838.00 | 224838.00 |
| | | | 1:5 | 110 | 80 | 174375.00 | 192600.00 | 180450 .00 | 180450.00 |
| 100 | 100 | 1 | 1:1 | 98 | 98 | 9801.00 | 9802.00 | 9801.3333 | 9801.3333 |
| | | | 1:2 | 96 | 96 | 9604.00 | 9608.00 | 9605.3333 | 9605.333 |
| | | | 1:5 | 90 | 90 | 9025.00 | 9512.50 | 9033.3333 | 9033.3333 |
| | | 1.5 | 1:1 | 97 | 97 | 14553.375 | 14556.75 0 | 14554.50 | 14554.50 |
| | | | 1:2 | 94 | 94 | 14113. 50 | 14127.00 | 14118.00 | 14118.00 |
| | | | 1:5 | 85 | 85 | 12834.375 | 12918.750 | 12862.50 | 12862.50 |
| | | 2 | 1:1 | 96 | 96 | 19208 .00 | 19216 .00 | 19210.667 | 19210.667 |
| | | | 1:2 | 92 | 92 | 18432.0 | 18464.00 | 18442.667 | 18442.667 |
| | | | 1:5 | 80 | 80 | 16200.00 | 16400.00 | 16266.667 | 16266.667 |
| | | 5 | 1:1 | 90 | 90 | 45125.00 | 45250.00 | 45166.667 | 45166.667 |
| | | | 1:2 | 80 | 80 | 40500.00 | 41000.00 | 40666.667 | 40666.667 |
| | | | 1:5 | 50 | 50 | 28125.00 | 31250.00 | 29166.667 | 29166.667 |
| | | 9 | 1:1 | 82 | 82 | 74529.00 | 75258.00 | 74772.00 | 74772.00 |
| | | | 1:2 | 74 | 74 | 68121.00 | 69642.00 | 68628.00 | 68628.00 |
| | | | 1:5 | 10 | 10 | 27225.00 | 45450.00 | 33300.00 | 33300.00 |



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**Result and Discussion:**

Some value of pond volume are given above (Table) as per calculation of different volume calculation method for comparing and checking out the results of newly developed AD's volume calculation method, where some pond top Length and top Width is assumed with varying side slant (slope) and depth. We have given volume of two types of ponds- rectangular and square pond with different top Length-Width, depth and side slant (slope).

From the results as shown in the table it is clear that when we use average Length-Width method for calculating volume then result is less than actual pond volume which is because of non-consideration of some part of pond's four corners. Again when volume is calculated by average top-bottom area method, then result is more than actual pond volume which is due to repeated consideration of some part of the pond's four corners.

From the results shown in the Table, it is also clear that actual pond volume can be calculated by using complicated cuboid-triangle-pyramid method which is really complex. The result of the AD's pond volume method is also exactly same with that cuboid-triangle-pyramid method. AD's pond volume method is almost similar with average top-bottom area method except the new incorporation of swap area.

Further, from the results shown in the table it is clearly understandable that pond volume calculated out by presently used method differ significantly with slant side (slope) and depth of the pond; means as either side slant (slope ratio) or depth and/or both increase, the volume difference from actual volume also increases.

**CONCLUSION:**

Now, we can conclude that the newly developed AD's pond volume formula has the following features :

- Gives accurate volume of pond.
- Very simple and easy to calculate.
- No need to dissect the pond into several other structures.
- No need to use the area formula of various structure(s) exœpt rectangle.
- Chances of error or mistake in calculation is too less.

The newly developed AD's pond volume method is the simple method of calculating volume of a pond that gives the accurate volume of the pond. The swap area concept can be used for any type of pond structure for calculation of accurate pond volume. When we cross multiply any one variable factor of standard area formula of rectangle (square) structure between top and bottom and calculate out the swap area by taking average of that two cross



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variable factor multiplication area (CVFMA) then we can get accurate volume of a pond very easily. Further we can calculate accurate volume of a pond with a two different Length-ward and Width-ward side slant/slope by using AD's pond volume formula by same manner. We can find out triangular shaped pond volume by swapping one factor of area either base or hypotenuse between top and bottom considering area of triangle = 1/2 x base x hypotenuse; similarly for circular pond volume by swapping one factor of area formula between top and bottom considering area of circle = $\pi.r.r$ instead of $\pi.r^2$.

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