EVALUATING THE ENERGY BALANCE SHEET ARTEMIA OF UREMIA LAKE AND THE METHODS OF OPTIMIZING ITS

Procjena energetske bilance artemije jezera Uremia i metode njezine optimizacije

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Abstract

In this study, an energy balance sheet was evaluated for the production of artemia in the Fasandoz plain of Miandoab. The research was done in 8 earthen ponds, with 2 ponds of 0.7 hectares and 6 ponds of 0.3 hectares. According to the results of the semi industrial research center in the Fasandoz plain in western Azerbaijan province, sampling shows that the biomass of artemia average 40 tons per year. According to the energy efficiency of the cyst and adult artemia compounds, the energy balance sheet is calculated as a function of biomass and protein. The amount and energy efficiency (ratio of data to saving) is estimated as a function of biomass as 0.048, and as a function of protein as 0.018. The most consumed energy is in response to application of hen fertilizer (47.74 percent) and gasoline (29.4 percent), and the least energy is consumed as required for releasing cysts (0.001). To produce brine shrimp in Uremia Lake, the bisexual Artemia urmiana should be used. Recommendations are provided for the optimal consumption of energy harvest of cysts in artemia breeding pools. In ponds designed to produce artemia, a large amount of lime should be added in the preparation stage, to increase the alkalinity of the water, such that with frequent fertilization until the end of the cycle, there is no reduction of pH in the water. The results indicate that at high salinity, artemia populations will decrease in the ponds and fewer cysts will be produced. Cytogenesis of Artemia urmiana occurs at low temperatures, such that cytogenesis should not be attempted during warm seasons.

Key word: Artemia uremia, artemia production, Fasandoz region, energy efficiency.

Sažetak

U radu je procijenjena energetska bilanca proizvodnje artemije na visoravni Fasandoz u području Miandoab. Istraživanje je obavljeno u 8 zemljanih bazena, dva površine 0,7 ha i šest površine 3 ha. Rezultati uzorkovanja industrijskog Istraživačkog centra na visoravni Fasandoz u zapadnoj azerbejdžanskoj provinciji pokazuju da proizvedena godišnja biomasa artemije prosječno iznosi 40 tona. S obzirom na energetsku efikasnost komponenti cista i odrasle artemije energetska bilanca je izračunata kao funkcija biomase i proteina. Količina i energetska efikasnost procijenjena je kao funkcija biomase na 0,048, a kao funkcija proteina na 0,018. Najveći postotak utrošene energije je zabilježen pri upotrebi

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kokošjeg gnojiva (47,74%) i benzina (29,4 %). Također su date preporuke za optimalnu energetsku iskoristivost cista artemije u uzgojnim bazenima. U pripremnoj je fazi potrebno koristiti velike količine vapna u zemljanim bazenima dizajniranim za uzgoj artemije kako bi se povećao alkalinitet vode i time do kraja ciklusa onemogućio eventualni pad pH izazvan frekventnim gnojenjem. Rezultati pokazuju da se pri visokom salinitetu brojnost populacije artemije i proizvodnja cista smanjuju. Do citogeneze Artemia urmiana dolazi pri niskim temperaturama, te ona ne može biti postignuta za vrijeme tople sezone.

Ključne riječi: Artemia uremia, proizvodnja artemije, regija Fasandoz, energetska efikasnost

INTRODUCTION / *Uvod*

Energy flow is one of the most important subjects in agricultural ecology. In the different parts of the world, the ratio of input and output energies are calculated in different agricultural ecosystems (Kochaki & Hosseini 1994; Dick & Doven 1985; Gillard 1993). One of the methods of estimating agricultural development and permanent production in agricultural areas is by the use of an energy flow method (Schroll 1994). Understanding the energy distribution method is important to the design and develop of agricultural management techniques. This requires the ecological management of energy and environmental stability that relates to the agricultural development (Giampietro et al. 1992; Hosier 1985; Okeef & Raskin 1985; Sharma & Singh 1994).

Uremia lake is second only to the Great Salt Lake in America, in its size, salinity, and as a natural environment for the brain shrimp, artemia. The area of Uremia Lake is 51450 square kilometers. Of that area, the actual lake is 5750 square kilometers, and 35120 square kilometers involves the 21 rivers that flow into the lake. About 4600 square kilometers are swamps, pastures and low coastal areas around the lake, and about 5800 square kilometers involve 40 floodways. The length of the lake, from north to south, ranges from 130 to 146 kilometers, and the width at the broadest part, located in the south, is about 58 kilometers. The narrowest section is between Zanbil Mountain and Eslami Island, and is about 15 kilometers. Most of the salt harvested from Uremia Lake is used as culinary salt. So, from a chemical point of view, the dissolved salt in the water is like that of chlorine lakes. The average annual salinity is about 163 grams of salt per liter (136 g/L). In addition the degree of hardness and electric conductibility is very high (Ahmadi 2002; Esmaeili 1996; Pickran mana 1996; Van spin 1996).

The only organisms living in Uremia Lake are *Artemia urmiana*, *Halophile omorpha, Halophyte ephedrine* and some species of phytoplankton.

Artemia is a small organism, belonging to the class arthropoda, and the crustacean subclass. This organism gradually evolved from a freshwater species, to salt water and finally to very saline water. This environment has resulted in the restriction of other organisms, such that natural enemies such as fish are not present.

Therefore, artemia becomes a monoculture organism living in 5 to 250-ppt salinity. The nutritional value of adult artemia species is: 50 to 69 percent protein, 2 to 19 percent lipid, 9 to 17 percent carbohydrates, and 9 to 11 percent ash. The unique characteristic of this crustacean organism and small trakopoda, is its embryonic shape, and its dormant period as a cyst, which can be reliably harvested as a food source. Artemia is a non-selective filter-feeding organism, whose feed particles range in size from 1 to 50 microns (Ahmadi 2001; Esmaeili 1996; Pickran Mana 1996; Van spin 1996).

Artemia is distributed extensively over the earth, living in lakes and salty ponds in tropical and semi-tropical areas. At present, the existence of artemia is reported in 5 continents of the world. According to published statistics, this species is the most important source of cysts in the world, providing 2000 tons of cysts yearly. From the Great Salt Lake, 7 varieties of artemia are recognized. One genus of artemia, *Urmiana* from artemiidae family, was first recognized and reported in Uremia Lake in 1900 by Gunther. This organism is 8 to 11 millimeters long, with 11 pairs of trakapoda feet, and with abundant filaments suitable for swimming. Ova grow in the two uterine tubes in the abdomen (Ahmadi 2001; Esmaeili 1996; Van spin 1996).

The reproduction of artemija can be sexual, and asexual through parthenogenesis. In Uremia Lake, parthenogenesis has not been observed, but it is possible that it occurs. Both methods of reproduction result in egg laying and viviparous oviparity. In the oviparity process, four factors are influential, including temperature (25 centigrade), oxygen (above 2-ppm), salinity (low of 15 ppm), and food (abundance). If one of the above factors is suboptimal, it results in unsuitable reproductive conditions, and leads to the laying of cysts (Esmaeili 1996; Van spin 1996).

Brain shrimps cysts have been commercialized for hatching as a live feed for cultured aquatic species. They are especially important in the culture of shrimp, being

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used to grow, and to expedite the sexual maturation of shrimp. Artemia is also used as a protein source for human, cattle, and birds. And it is used to produce pure and high quality salt from the sea and lakes. It is used in genetic research (because of its short lifecycle and abundant generations). Artemia can be enriched using vitamins, antibiotics, etc. and it is used to transfer these materials to the cultured species thus increasing their growth.

Providing food to its population is one of the most important priorities of governments. In addition to discovering new food sources, we must properly exploit existing sources of nutrition. A biophysical and energetic analysis of agricultural ecosystems is essential to this efficient and effective use (Schroll 1994). Also, understanding energy distribution is important to the design and development of agricultural management tools, requiring stable environmental and energetic management as it relates to ecological development (Pickran mana 1996; Dahiphale & Pawar 1985; Pimental et al. 1983; Hosier 1985; Giampietro et al. 1992).

Scientific methods must be used to determine the stability and consistence of production and pollution in ecosystems. This can be accomplished by evaluating an energy balance sheet and energy efficiency, by determining and recognizing the kinds and levels of energy consumption and determining which is most relevant. (Dahiphale & Pawar 1985; Dick & Doven 1985; Giampietro et al. 1992; Hosier 1985; Peterson et al. 1990).

Materials and Methods / *Materijali i metode*

In this study, an energy balance sheet was evaluated for the production of artemia in the Fasandoz plain of Miandoab, using information received from questionnaires issued to the related authorities of each area. Irrelevant responses were disregarded.

This research was done in 8 earthen ponds, with 2 ponds of 0.7 hectares and 6 ponds of 0.3 hectares. Artemia-breeding systems in inseminated ponds were prepared carefully in relation to prescribed conditions of liming and fertilization. Otherwise, problems including the subsiding of cysts or the growth of phytobentos in the depth of ponds could occur.

Liming in the artemia-breeding ponds is done for two chemical and biological reasons. Lime apart from causing the destruction of the cochlea, copepods and phytobentos at the bottom of the ponds, acts as a neutralization reservoir in the pools. A suitable pH is considered between 7.6 and 7.8, which should be maintained per 0.9 units. This is maintained by measuring the pH of the pond's water source, and by broadcasting 500 kilogram of lime over the surface per hectare of pond.

But in Fasandoz this amount was not sufficient. Because the pH of the salt water source of underground waters in the Fasandoz region is about 6.9, and because of intense penetration and high evaporation in this region during the breeding period, it is necessary that water is constantly pumped. Because the pH of these waters is very low, direct pumping into the pond has a significant effect on the pH of the pond's water. Therefore, initially a high liming rate of about 8 to 10 tons into the breeding ponds was applied. Then the input water source of the breeding pools was transferred to the green pool. After liming and fertilizing of the green pond, it was directed to the breeding ponds.

Fertilizing of the ponds starts quickly after the initial influx of water. Following this, 60 kilograms of urea fertilizer and 15 kilograms of mono aminophosphate was added weekly for relatively good dehiscence in the ponds. Then 50 kilograms of hen fertilizer and 30 kilogram of sugar beet molasses was added daily to the pools to have a continuing effect on plankton dehiscence.

The labor required for this project was as follow: 2 people for 12 months and 6 people seasonally, with one additional collection person for 6 months.

The collected data were averaged and the averaged data analyzed. All related formulas and available data statistics are used to express the amount of energy per saved unit in kilocalories (Esmaeili 1996; Hassanzadeh Gort Tappeh and Mazaheri 1996; Van spin 1996; Dahiphale & Pawar 1985; Okeef & Raskin 1985; Hosier 1985), such that the energy per saved unit is specified.

In the work of Miandoab (2007), the amount of each of the consumed factors and savings per year was determined by using specific formulas, using available statistics and information, and the questions from relevant authorities (Heidar Golinejad Kenari & Hassanzadeh Gort Tappeh 2004; Okeef & Raskin 1985; Berthelemy and Okazakin 1986).

In the next stage, the energy efficiency was calculated (the ratio of data to saving) as follows (Hassanzadeh Gort Tappeh & Mazaheri 1996; Kochaki & Hosseini 1994):

$$\text{Efficiency of livingmass functional energy} = \frac{\text{Livingmass production energy}}{\text{Total of consumed energy}}$$

$$\text{Efficiency of protein functional energy} = \frac{\text{Protein production energy}}{\text{Total of consumed energy}}$$

According to the percent of artemia cyst and adult artemia compounds we can calculate the total

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energy of each of the cyst artemia and adult artemia compounds, the ratio of produced to consumed energy (data to saving), or the energy efficiency and the ratio of consumed to produce energy (Esmaeili 1996; Hassanzadeh Gort Tappeh et al. 2001; Hassanzadeh Gort Tappeh & Mazaheri; Van spin 1996; Giampietro et al. 1992; Dick & Doven 1983; Blamy & Chapman 1981; Hulsbergen et al. 2001; Kochaki & Hosseini 1989).

RESULTS / *Rezultati*

According to the results of the semi industrial research center in the Fasandoz plain in western Azerbaijan province in 2007, sampling shows that the biomass of artemia in 2006 averaged 40 tons. But because this amount was determined at the research center, the functional amount of biomass in Uremia Lake appears less. The levels of artemia protein is determined by multiplying by a function of the biomass (Esmaeili 1996; Pickran mana 1996). So the produced energy in the semi industrial research center of west Azerbaijan province is illustrated in table 1.

According to the energy efficiency of the cyst and adult artemia compounds the energy balance sheet is calculated as a function of biomass and protein and is showed in table 2.

Table 2 demonstrates the energy efficiency and the amount of necessary energy (consumed) to produce the unit of biomass and protein of *Artemia urmiana*. Hassanzadeh Gort Tappeh et al. (2001), Hassanzadeh Gort Tappeh and Mzaheri (1991) Belimi and Chapman (1981) in calculating the produced energy from different sources in surface units, regarded the other available materials in the produced product, less the nutritional value in water and fiber.

In this study, the amount and energy efficiency (ratio of data to saving) is estimated as a function of biomass as 0.048, and as a function of protein as 0.018.

The percentile of consumed energy of each of the factors and savings are provided in Fig 1. This shows that the most consumed energy is in response to application of hen fertilizer (47.74 percent) and gasoline (29.4 percent), and the least energy is consumed as required for releasing cysts (0.001).

DISCUSSION / *Rasprava*

Because of the low ratio of produced to consumed energy, it can be inferred that the consumed energy is unimportant in the production of artemia, and that this level of energy could results in a dangerous condition and instability of production. Because of the high levels of energy required to produce artemia, it is important to minimize the effects of weather conditions, feed availability or other related problems as they effect the process. The optimal use of energy seems important in the production and nourishment of artemia, especially in the case of hen fertilizer (47.74 percent), which allocates the greatest levels of energy to the production of artemia. Use of hen fertilizer extract instead of direct use can be a suitable addition to the reduction in the consumption of fertilizer. The direct use of hen fertilizer results in the development of cysts and increase the biomass of artemia due to the existence of external nourishment

Table 1. the produced energy of adult artemia in the Artemia Research Center in Fasandoz plain of Miandoab (2007)

Tablica 1. proizvodnja energije odrasle artemije u Istraživačkom centru za artemiju na visoravni Fasandoz, Mioandoab (2007.)

Kind of produced energy (kilogram)	Amount of energy per unit (kilocalorie)	Amount of production (kilocalorie per year)	Amount of produced energy (kilocalorie per year)
The function of living mass	384/5	40000	15380000
The function of protein	238	23800	5664400

Table 2. the energy balance sheet as the function of biomass and protein in the Artemia Research Center in Fasandoz plain of Miandoab (2007)

Tablica 2. energentska bilanca kao funkcija biomase i proteina u Istraživačkom centru za artemiju na visoravni Fasandoz, Mioandoab.

Kind of produced energy (kilogram)	Amount of energy per unit (kilocalorie)	Amount of production (kilocalorie per year)	Amount of produced energy (kilocalorie per year)	The ratio of produced to the consumed energy	The ratio of consumed to the produced energy
The function of biomass	384.5	40000	15380000	0.048	20.42
The function of protein	238	23800	5664400	0.018	55.46

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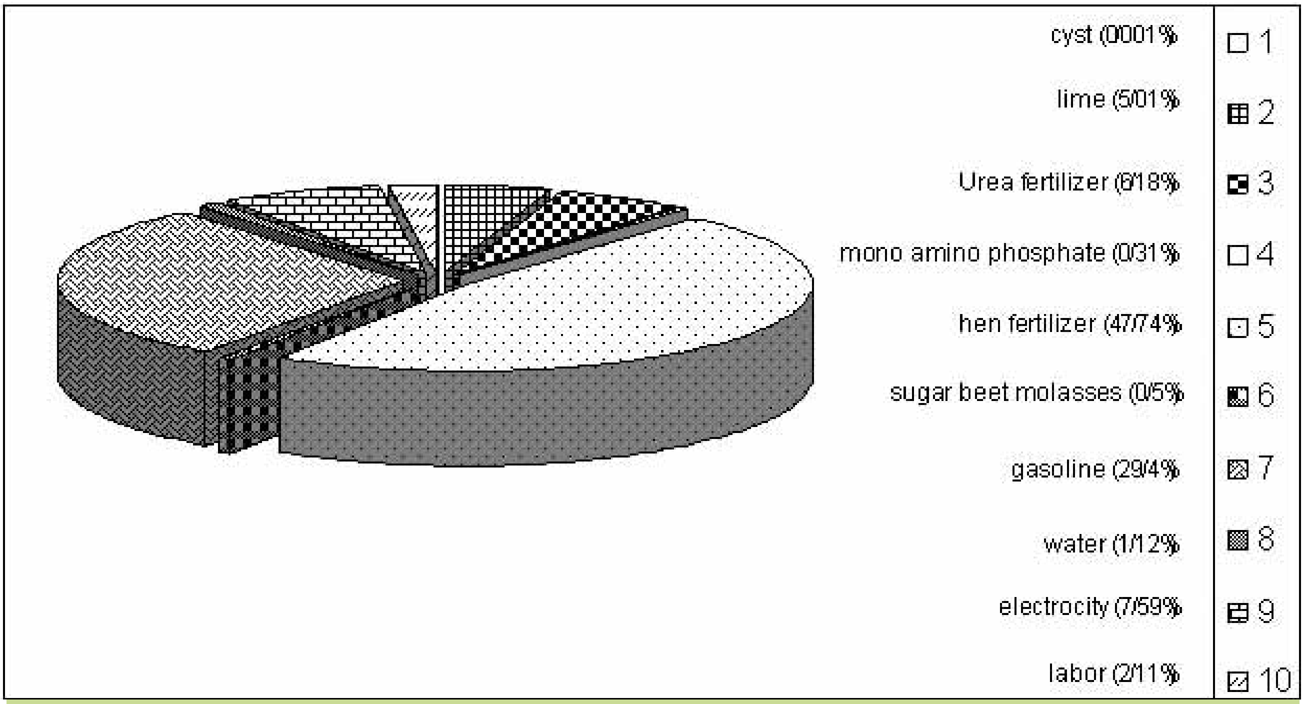

Figure 1. The percent of consumed energy of each of the factors and savings in the research center of Fasandoz plain in West Azerbaijan (2007).

Slika 1. Postotak potrošene energije svakog faktora i ušteda u istraživačkom centru Fasandoz ravnice u Zapadnom Azerbejđanu (2007.)

(Ahmadi, 2002; Tackaert, 1992). The feeding of artemia nauplii is not difficult while nutrients are stored in the ponds. Because of filtration of the influent waters of the ponds, and the high salinity of water, zooplankton and bonitas which consume the zooplankton don't enter in the pools, because of the loss of the second level of their ecological food chain. Also, with the increase of the required organic and inorganic materials, the growth of the first level of their food chain in the ponds will be extensive.

So the optimum growth of phytoplankton has to be established in the ponds. But after the stocking of the feeding ponds, it is important to manage the production of food and the control of the environmental conditions of the second level of the food chain. Because, the more nauplii released, and the more adults occupy the pond, the more difficult is the management of the production of the supply of the required plankton. This care lead to problems feeding the population of the adult artemia in the ponds, as the primary consumers, as in decrease of the population of phytoplankton. And if the primary plankton population decreases, their reproduction will be limited. It is clear that the increase in the population of phytoplankton in the ponds depends on two factors: the concentration of elements required for photosynthesis such as carbon, nitrogen, phosphorous and additional microelements; and more importantly the existence of a significant primary population to produce and reproduce the next generations. If a reduction occurs in the primary population of plankton within the feeding ponds, their replenishment is very difficult, even with very high fertilization. In addition, excess fertilization will decrease the oxygen level in the ponds, and increase the ammonia levels, leading to severe mortality of the artemia populations. So, the ponds with the population of artemia decreasing over time. The population of the artemia living in the pools can be controled by fishing, and by restoring the population of plankton, what results in an increase in the population of the living artemia (Ahmadi, 2001; Tachaert, 1992). Accurate management of the feeding of artemia will increase the energy efficiency by the optimal use of hen fertilizer.

Recommendations are provided for the optimal consumption of energy harvest of cysts in artemia breeding pools. In ponds designed to produce artemia, a large amount of lime should be added in the preparation stage, to increase the alkalinity of the water, such that with frequent fertilization until the end of the cycle, there is no reduction of pH in the water.

To produce artemija in Uremia Lake, the bisexual Artemia urmiana should be used. Published sources describe the effect of salinity to the cytogenesis of artemia.

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It is not recommended to use the salinity above 150 ppt in the breeding ponds to produce cysts. Increasing the salinity will reduce the concentration of chlorophyll in the ponds, and management of chlorophyll levels of ponds is difficult at high salinities. The results indicate that at high salinity, artemia populations will decrease in the ponds and fewer cysts will be produced.

Management should be done in a seasonally suitable manner to optimize cyst production. Environmental factors such as temperature will affect cytogenesis. The factors most effecting artemia cystogeny and increasing cryogens in embryo females are the reduction of oxygen in induction conditions (Dutrieu, 1960), at 2-ppm oxygen concentrations (Sorgeloose 1989). Stress inducing conditions such as low oxygen, feeding conditions and temperature cause an increase in lactic acid in the artemia tissues. There is also a decrease in the pH within the tissues. When the inter-tissue pH is less than the environmental pH, significant stress is incurred which leads to cytogenesis in artemia. Cytogenesis of *Artemia urmiana* occurs at low temperatures, such that cytogenesis should not be attempted during warm seasons.

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