



O'Neill, J. D. and Telmer, K. (2017) Estimating Mercury Use and Documenting Practices in Artisanal and Small-scale Gold Mining (ASGM); UN Environment, Geneva, ISBN 978-0-9939459-7-7.

Access online at:

<http://web.unep.org/chemicalsandwaste/nap-starter-kit>
<http://www.artisanalgold.org>

Annex A4. Equations and Example Calculations

i. Gold Calculations

Correcting Impure Gold to 24K or 100% Pure Equivalence

$$\text{mass pure gold} = (\text{mass impure gold}) \times \frac{(\text{purity of impure gold})}{(\text{purity of pure gold})}$$

If the purity of your gold is stated in karats:

$$\text{mass pure gold} = (\text{mass impure gold}) \times \frac{(\text{karatage impure gold})}{24}$$

If the purity of your gold is stated as percentage:

$$\text{mass pure gold} = (\text{mass impure gold}) \times \frac{(\% \text{ purity of impure gold})}{100}$$

e.g.1. 50 g of 18K gold = (50 g) × (18/24) = 37.5 g of 24K gold

e.g.2. 70 g of 80% pure gold = (70 g) × (80/100) = 56 g of 100% pure gold



Gold Yield from Ore (Gold Production)

$$\text{gold yield} = (\text{mass ore}) \times (\text{recoverable ore grade})$$

e.g. 1. How much gold is yielded from 30 T of ore that has a recoverable grade of 5 g/T?

$$\text{gold yield} = 30 \text{ T} \times 5 \text{ g/T} = 150 \text{ g of gold}$$

e.g. 2. The average bag extracted by miners on site weighs 10 T. The recoverable ore grade is 6 g/T. How much gold is in each bag?

$$\text{gold yield per bag} = 10 \text{ T/bag} \times 6 \text{ g/T} = 60 \text{ g of gold per bag}$$

ii. Mercury Calculations

Mercury recovery

Mercury-to-gold (Hg:Au) Ratio

See guidebook Chapter 1, 7.4. Mercury-to-Gold (Hg:Au) Ratio (p.73)

And Chapter 2, 4.3.6. Research Steps to Measure a Hg:Au Ratio at a Processing Unit (p. 124).



iii. Throughput Calculations

Sluice Throughput

$$\text{throughput rate} = (W \times L \times \text{water depth}) \times (\text{water velocity})$$

$$\text{daily slurry throughput} = (\text{throughput rate}) \times (\text{hrs operating})$$

$$\text{daily ore throughput} = (\text{daily slurry throughput}) \times (\text{mass of sediment per m}^3 \text{ of slurry})$$

e.g.

Field researchers measure the dimensions of a sluice and the velocity of the ore slurry passing through it by timing the passage of a floating object. They interview the processors to find out how many hours per day the sluice is operating. They also fill a 1L soda bottle with the slurry entering the sluice and weigh it. They then drain the water out of the 1L bottle of slurry and weigh the sediment. They find:

Sluice length = 14 m

Sluice width = 0.8 m

Water depth = 0.01 m

Water velocity = ~1.25 m/s

Hours operating = 20 hr/d

1 L slurry = 1285 g

Mass of sediment in 1L of slurry = 0.463 kg

What is the daily ore throughput of the sluice?

Throughput rate = $0.8 \text{ m} \times 0.01 \text{ m} \times 1.25 \text{ m/s} = 0.01 \text{ m}^3/\text{s}$

Daily slurry throughput = $20 \text{ hr/d} \times 3600 \text{ s/hr} \times 0.01 \text{ m}^3/\text{s} = 720 \text{ m}^3/\text{d}$

Daily ore throughput = $720 \text{ m}^3/\text{d} \times 463 \text{ kg/m}^3 = 333360 \text{ kg/d} = 333 \text{ T/d}$



iv. Equations and Calculations for Processing Sites

Calculations

Single Processing Unit (Daily)

** important: each of these calculations is for one specific processing unit type. Calculate this information for each unit type (e.g., unit 1 = sluice, unit 2 = rastra, unit 3 = panning).*

Daily 24K gold production (g/R/d)

Daily throughput (T/unit/d) x ore grade (g/T)

Correct karatage to 24K (as in Section 9.1.1.)

Daily mercury loss (g/R/d)

Unit-specific daily 24K-Au production (g/unit/d) x unit Hg:Au ratio

Daily number of active processors (workers/unit/d)

Shift count (workers/shift) ÷ shift length (hrs/shift) x 24hrs

Daily active miners required to produce the daily throughput (workers/unit/d)

Daily throughput (T/unit/d) ÷ miner ore prod (T/workers/d)



Calculations

Site-level Information (Daily)

** once calculations are made for each type of processing unit on the site, the averages for each processing unit can be combined into site-level information.*

Daily 24K gold production (g/site/d)

Average of unit type 1 daily 24K gold prod (g/unit1/d) x #unit1/site

Also calculate for unit type 2, type 3, etc. and then sum production values for all unit types.

Daily mercury loss (g/site/d)

Average of unit type 1 daily Hg loss (g/unit1/d) x #unit1/site

Also calculate for unit type 2, type 3, etc. and then sum production values for all unit types.

Daily number of active processors (workers/site/d)

Average unit 1 daily number of active processors (workers/unit1/d) x #unit1/site

Also calculate for unit type 2, type 3, etc. and then sum production values for all unit types.

Daily number of active miners (workers/site/d) – Option 1

Average unit 1 daily active extractors (workers/unit1/d) x #unit1/site

Also calculate for unit type 2, type 3, etc. and then sum production values for all unit types.

Daily number of active miners (workers/site/d) – Option 2

Average site-level daily throughput (T/site/d) ÷ average miner ore production rate (T/workers/d)



Calculations

Regional-level Information (Daily)

Daily 24K gold production (g/region/d),

Daily number of active processors per region (workers/region/d), and

Daily number of active miners per region (workers/region/d).

Extrapolation from site-level data using a known piece of regional information, e.g., number of processing units in the region. (see Section 7.2: *Extrapolating Regional Estimates*).

Daily mercury loss (g/region/d)

Daily 24K gold production (g/unit1/d) x (% of production yielded by unit type 1) x (Hg:Au Ratio for unit type 1)

Also calculate for unit type 2, type 3, etc. and then sum production values for all unit types.

Regional-level Information (Annual)

Annual 24K gold production (g/site/y)

Daily 24K gold production (g/region/d) x active days per year (d/y)

Convert to kg/region/y by dividing by 1000.

Annual mercury loss (g/site/y), Option 1

Daily Hg loss (g/region/d) x active days per year (d/y)

Convert to kg/region/y by dividing by 1000.

Annual Hg loss (kg/site/y), Option 2

Annual 24K gold production (kg/region/y) x (% of production yielded by unit type 1) x (Hg:Au Ratio for unit type 1)

Also calculate for unit type 2, type 3, etc. and then sum production values for all unit types.

Number of active processing workers (worker/region/y)

assumed equal to the daily statistic

Number of active extraction workers (workers/region/y)

assumed equal to the daily statistic



Calculations

National-level Information (Annual)

Annual 24K gold production (kg/country/y)

Sum all 24K gold production (kg/region/y) for each of the major ASGM mining regions in the country

Annual mercury loss (kg/country/y)

Sum all Hg loss (kg/region/y) for each of the major ASGM mining regions in the country

Number of active processors (workers/country)

assumed equal to the daily statistic

National active extraction workers (workers/country)

assumed equal to the daily statistic