purpose of the developing the KIANA Code:
Design and development of a radioecological domestic user friendly code for
calculation of individual /collective radiation doses and concentration due to
radionuclides airborne release during the accidental and normal operation in
nuclear installation

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Introduction

KIANA Advance Computational Computer Code

The novelties in this study

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Contents (main exposure pathways)

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Introduction of KIANA Code & model structures:

- The research in this study is based on:
  i. atmospheric dispersion of radionuclides,
  ii. dose and risk model development,
  iii. validation of the model & KIANA Code & comparison with main available CODES
  iv. Discharge Conditions of radionuclides in to the surface waters
  v. Discharge Conditions of radionuclides in to the sea/smal and big lakes/rivers

KIANA Code & model that developed for this study was planned to predict Radiation doses/Collective doses and risks in the case of a nuclear accident and normal operation in nuclear installations and for some pathways would be cal. of Concentrations of RN……and can calculate of radiochemical release in Chemical Facilities that also were focused on in KIANA Code structures

Short-range dispersion models & long-range atmospheric dispersion models are used in KIANA CODE

For validation of The KIANA code developed for this study we took the CROM, AIREM, RECASS models & SRS No.19 IAEA as reference
Fig. 1. KIANA Code STRUCTURE for some exposure pathways
Fig. 2. Code Algorithms of contamination of plant products as a function of time results from the direct contamination of the leaves and the activity transfer from the soil by root uptake and re-suspension that used
Fig. 3. Code Algorithms calculation of Inhalation doses for each incremental time step (in days) that used in construction of KIANA Advance Computational Computer Code.
Fig: 4 All typical summarize radiation dose exposure pathways in KIANA CODE can be seen in Figure

![Radiation exposure diagram](image-url)
Objective of DEVELOPING of the KIANA Code:

✓ Developing of the Domestic Code and Software in our country that this is for the first time in our Country that can be useful for relevant radiations safety assessment researchers and PhD/MSc students and atomic organizations such as INRA/NNSD/AEOI/NRPD

✓ KIANA Domestic code can perform calc. of release of RN... in accident and normal for all possible exp. Pathways with together & IT WAS NESESERY FOR INRA/NNSD as Dose assessors/assessment Duties
Objective of DEVELOPING (Cont.)

✓ In developing systems for emergency preparedness in IRAN as well as providing for rapid decision-making relating to foodstuffs, the characterization of action plans based on KIANA CODE approach model predictions are likely to be appropriate.

✓ For chemical facilities as follows conditions:

I. The accidental release of a volatile chemical can present a threat to life and health far from the point of release that the KIANA Code can be used for this facilities in advanced

II. KIANA CODE be able use: the Air dispersion models that are central to predicting hazard zones associated toxic or flammable gas clouds. These models are used to predict how the concentration of a pollutant, once released into the air, varies with time and position in chemical facilities.

III. Some chemicals products are toxic by inhalation. For Calc. of dispersion of toxic pollutant in the atmosphere in chemical facilities that the KIANA Code can be used for this facilities.
The novelties in this study

The main features of this KIANA CODE and study can be summarized as the follows:

- It can be coupled with a dynamic dose and risk model with a long-range atmospheric transport model to predict the radiological consequences due to accidental releases & normal

- to perform the model simulation for NPP sites in BNPP as CASE STUDY specific data as far as it can be acquired and comparison able with CROM & AIREM & DOZA-M, RECASS, AMBER...

- A huge amount of data, such as radioactivity concentration in foodsuffs, pasture and doses, regarding the consequences of nuclear power plants’ accidents & NORMAL Cond. in literature were decreased and used for model development and its validation in KIANA CODE
The novelties in this study (cont.)

All Ingestion pathways important conditions are modeled in such a detailed way that in KIANA Code as “novelties” and as options for selections by Users such as:

- translocation conditions,
- transfer between soil-plant conditions
- feed-animal conditions,
- food processing and storage conditions,
- Weathering conditions,
- dilution in the plant are all taken into account.

- Time dependency in radionuclide transfer in the environment considering

- Food harvesting conditions
- sowing times conditions,
- feeding regimes conditions,
- the growing up of a person are all taken into account.
The novelties in this study (cont.)

- ALL FOLLOWING CONDITIONS HAD BEEN CONSIDERED in KIANA Code structures:
  - soil density
  - percolation velocity
  - water content of soil
  - distribution coefficients
  - fixation rates of radionuclides formulated
  - interception factors
  - weathering rate constant
  - translocation factors
  - distribution coefficients
  - depth of root zone conditions
  - water content of soil conditions
  - percolation water velocity conditions
  - dilution factor, fixation factor
  - dose conversion factors
  - processing factors and storage time for food products have been kept as default for the software, since they are based on recent knowledge and make the results more realistic in KIANA CODE
  - concentration of activity in the root zone of soil

- Plant contamination due to resuspension:
  - due to resuspension is proportional to the activity in the soil

- Contamination of animal products:
  - from the activity intake of the animals and the kinetics of the radionuclides within the animals
  - from the concentration of activity in the different feedstuffs and the feeding rates

- Soil ingestion is also considered in KIANA CODE

- Transfer of radionuclides from fodder into animal products is calculated
The novelties in this study (cont.)

- Ingestion Pathway THAT HAD BEEN CONSIDERED in KIANA Code:
  - Yield of grass and agricultural food products conditions
  - Harvesting and sowing time of grass and agricultural products
  - Translocation within plants conditions
  - Interception conditions
  - Weathering from plant surfaces conditions
  - Dilution of radionuclide concentrations due to plant growth conditions
  - Uptake by plant roots conditions
  - Migration within the soil and Plant contamination due to resuspended soil
  - Different livestock feeding regimes conditions
  - Storage times for fodder and human food products
  - Changes in radionuclide concentrations due to food processing
The novelties in this study (cont.)

✓ The model algorithm, which the software developed for this study:

i. **to be able** to calculate inhalation/external/internal doses from re-suspension, individual doses in terms of both average and maximum habits, collective doses and late risks

ii. The long/short-range transport model, which the KIANA Code developed for this study were **coupled with some soft wares**, were also upgraded to increase the number of pollutants modeled to provide us easiness,

✓ In the case of **short-term deposition** of radionuclides after a nuclear accident, the radionuclide concentration in foodstuffs that is strongly dependent on the date(or season) when the deposition occurs had been developed and considered in KIANA

✓ on the time after the deposition due to factors such as **crop growth** and **biokinetics** of radionuclides ingested by the animals had been considered in the code.
The novelties (cont.)

- Wet interception also has been modeled & taking into account rainfall in KIANA code.
- Translocation may be modeled on a timely basis, namely plant vegetation stage also be considered in KIANA code.
- Foodstuff types also be increased in the model in KIANA code.
- Food consumption amount of the people can be modeled as well, and relevant food distribution regime may increase the realism of the model in KIANA code.
- Reduction factor, namely, type of house and \textit{time spent indoor} and \textit{outdoor}, is also highly location dependant parameter and also be modeled on KIANA code to increase the reliability of the modeling study.
PRIORITY of the Developing of the KIANA Code (I mean why?):

- Some codes can be modeled only a few nuclides, such as DYNACON code,

- some only can produce outputs of radioactivity concentration in plants or animal products, not for calc. of the doses such as FARMLAND, COMIDA and DYNACON codes

- A few codes only can also calculate the risks, for example: RESRAD and RODOS

- the food chain model of which is based on Ecosys-87

- Some code can be used only in Normal Cond. such as CROM & AIREM

- In some radioecological models, such as: COMIDA, CRLP and TERNIRBU the soil compartment is modeled in such a way that it is divided into many layers: surface layer, root layer, and deep soil layer without calculation of doses…
PRIORITY of the Developing of the KIANA Code:

- All natural phenomena important for ingestion pathway modeling is taken into consideration in the KIANA code.
- Whereas, time dependent translocation, layered soil compartment, wet interception, and mushroom pathway are available in the KIANA code model (but for mushroom pathway we didn’t use it in the code).
- **In KIANA code we developed all mentioned exposure pathways as new options for users with together IN NORMAL And INCIDENTAL Cond.**
Main and Common User-friendly options

Contents (cont.)

- Developed software is implemented in C#
- All model parameters are kept in external editable data files, so that they can easily be exchanged or modified without changing the program. Such an approach introduces flexibility to simulate different release conditions, environments, and numbers of feedstuffs and foodstuffs. Current software can perform modeling well for unlimited isotopes, 70 years, 13 food stuffs and pasture, 8 animal products, 4 different age groups, i.e. infant, child, teen and adult (and can be selected by USERs),
- Maximum and Average individuals in terms of food consumption habits, correction coefficients for gamma dose rate and time spent outdoors had been considered in KIANA
The KIANA Code can produce individual dose results annually for each isotope and pathway, and the sum for all isotopes and pathways as well, and for the total collective dose.

The KIANA Code can also produce monthly activity results in grass and animal food products and concentrations results of agricultural food products at each harvest year after the accident & normal.
There are some input files necessary to run KIANA CODE:

IN KIANA code we use:

1. multiple wind measurements in both the horizontal and vertical directions
2. terrain effects vertical and horizontal wind shear
3. surface roughness
4. deposition and variable atmospheric stability classes
5. start and end date of simulation (in Julian days)
6. simulation time (in years)
7. simulation time (in days) of atmospheric dispersion model or time interval (in days) of measurement data
8. fixation rate, distribution coefficient, decay rate, DCF, RCF of radioisotopes, TF of grass, plants and animals for radioisotopes, ground deposition velocities, wet/dry/rainfall deposition, vtop level affecting boundary layers correcting factor on plume
9. biological turnover rate of radioisotopes for animals
Main and Common User-friendly options

Contents (cont.)

a) food consumption amount for each age group (maximum and average),
b) breathing rate for each age group,
c) reduction factor for shielding for each age group (average and maximum individual),
d) growth dilution of grass,
e) fraction of activity translocated to the root zone,
f) interception fraction for grass and other plants,
g) translocation for each plant,
h) soil density,
i) water percolation velocity
j) weathering rate for grass and leafy vegetables,
k) depth of root zone,
l) storage times and processing factors for each foodstuff
m) population data of big cities & yields of different plants
Main and Common User-friendly options

Contents (cont.)

i. sowing, vegetation and harvesting times of different plants,

ii. monthly feeding rates of each animal,

iii. air concentration data (in days) for each isotopes for each exposure path ways (river-atmosphere-lakes-forest-sea … ),

iv. deposition data (in days) for each isotopes

v. External ground dose (in Sv) for infant and others (max-avg.) age group for each radioisotope for each year after the accident, and in normal at 6,8,412,16 sector-segments

vi. External cloud dose (in Sv) for each group for infant and others (max-avg.) age group for each radioisotope

vii. Inhalation dose and inhalation dose from re-suspension (in Sv) for each grid for each age group for each radioisotope

viii. Ingestion dose (in Sv) for each grid for each age (max-avg.) group for each isotope for each year after the accident and in normal, and ingestion dose (in Sv) incurred via consumption of each foodstuff,
Dose Pathways cal.:

- **Inhalation Pathway in KIANA Code structures:**
  - For **internal exposure**, the usual assumption is that daughter products produced in vivo adopts the absorption parameters of their parent, if they are produced in the respiratory or gastrointestinal tract, and the biokinetics of their parent, if they are produced after absorption to blood
  - **Inhalation from cloud**
  - **Inhalation from resuspension**

- **External Radiation Pathway**
  - exposure to the radioactive cloud or
  - exposure to the activity deposited onto surfaces

- **Cloud shine and ground shine** doses
  - Shielding due to migration of the radionuclides into deep soil is considered
  - Radionuclide concentrations accumulated on the ground and corrected for decay are calculated
Activity concentration of plant products:

- Pasture and 13 different plant products, i.e. corn cobs, spring and winter wheat, spring and winter barley, rye, fruits, berries, and root, fruit and leafy vegetables, potatoes and beet can be modeled by KIANA Code.
Foliar uptake of radionuclides used in KIANA Code

- Calculation of the contamination of plants must distinguish between plants that are used totally (leafy vegetables and grass) and plants of which only a special part is used.
- The activity concentration at time after the deposition is determined by the initial contamination of the plant and activity loss due to weathering effects (rain, wind) and radioactive decay and growth dilution.

- Activity concentration at the time of harvest
- Translocation factors for only the ripening stage is applied in KIANA Code

Root uptake of radionuclides: concentration of activity in the soil using transfer factor TFi that gives ratio of concentration of activity in plants (fresh weight) and soil (dry weight)
Dose Pathways cal. (cont.):

- The processing and storage of foodstuffs:
  - **Goal**: Calculating the concentration of activity in products is calculated from the raw product.
  - The processing and storage of foodstuffs in order to take advantage of the radioactive decay and dilution during these processes are taken into account in the KIANA Code.
  - The enrichment of minerals in the outer layers of grains and the fractionation in the milling products is considered.
  - The radioactive decay during processing and storage is taken into account in the KIANA Code.
  - Storage times are considered to be mean time between the harvest and beginning of product consumption.
Activity intake and exposure:

- The intake of activity by humans is calculated from the time-dependant concentrations of activity in foodstuffs and the human consumption rate.
- Food consumption data that is very important for calculating dose exposure by ingestion pathway is different depending on where people live.
- The dose $D_{ing}(t)$ due to ingestion of contaminated foodstuffs within time $t$ after the deposition was taken into account in the KIANA Code.
CONCLUSION

- In this study, development of main framework of the new dynamic Domestic dose calculation CODE has been introduced.
- KIANA CODE/ model is successfully applied to calculate the radiological/ radiation consequences of the atmospheric releases in the case of nuclear accidents and Normal. The number of radionuclides, feed and foodstuff types, and the number of age groups exposed to radiation, and period of calculation are flexible in the current software and can be regulated by USERS;
- their numbers may increase taking into account runtime and computer memory limitations
- THE normal conditions had been developed now in KIANA code
- THE accidental conditions for AIR exposure Pathways had been developed now in KIANA code
- The Rest Exposure Pathways will be developed up 5 next Months such as Under wather-food chain-sea,Gulf,loch,cove and inlet,…etc
CONCLUSION (Cont.)

• The validation part of this CODE proves that KIANA code has fairly good estimations in comparison to the observations in BNPP-1 FSASR, and it comparison able with CROM-AIREM-RECASS Express CODES etc. in Normal and accident for NUCLEAR AND CHEMICAL installations

• The KIANA code will be Registered in INRA/NNSD a.s.a.p after Compelation

• It can be used to assist in emergencies resulted from the accidents at nuclear facilities in BNPP-1 &3,4 and for another NPPs in the world

• We think it is necessary to have(technical and Financial) support for Developing of the Code by typical SPONSIORED
THANK YOU FOR YOUR ATTENTION
Have any Questions?